A multi-scalar assessment of global gas flaring: Implications for the management and development of inclusive gas flaring policies and the energy transition

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General Abstract

Gas flaring is a major complex environmental concern that needs to be understood as a whole system if it is to meet targets of zero routine flaring by 2030 and net zero emissions by 2050. Achieving these targets depends significantly on effective policies, regulations, and inclusive participation of all gas-flaring stakeholders at all levels. However, the current understanding of global gas flaring challenges is fragmented. This thesis aims to integrate multilevel governance, policy coherence, good governance, and energy justice to analyse global gas flaring issues and optimise policy solutions and regulations to stimulate progress towards targets of zero routine flaring by 2030 and net zero emissions by 2050. It considers options that encompass fairness and equity while supporting the energy transition. The objectives are to: 1) reconceptualise and enhance theories linked to global gas flaring by proposing a new perspective on global gas flaring issues. 2) analyse Nigeria's multilevel governance system and assess the policy coherence across gas flaring and energy sectors, 3) analyse the emergent perspectives on energy justice and global gas flaring and evaluate how agreement and disagreement among these views contribute to developing equitable and inclusive gas flaring policies and regulations, and 4) evaluate stakeholder preferences for different policies and regulatory options, determining the most optimised and effective to help eliminate routine gas-flaring by 2030 and achieve net zero emissions by 2050 whilst addressing good governance, justice, and fair implementation. The research uses mixed methods combining document analysis, semi-structured interviews, exit interviews, and expert surveys with representatives of 16 major gas flaring-affected countries (*n*=74). Interviews and surveys used purposeful snowball sampling. Findings showed: 1) a singular approach is ineffective, and a whole systems approach is needed to improve the overall gas flaring system; 2) policy coherence around gas flaring, including efforts toward climate change mitigation, has been slowed by political partisanship, poor governance, lack of regulatory compliance, and policy conflict between environmental protection and economic development priorities., 3) global stakeholders support zero-flaring, multi-scalar governance, and egalitarian rights-based approaches but have competing views on the practical mechanisms to achieve just outcomes, and 4) full implementation of gas flaring policies and regulatory framework criteria to limit temperature warming to 1.5°C, is considered the most effective policy alternative. Governments should take responsibility and implement bold and consistent gas flaring policies. However, meeting zero routine flaring and net zero emissions targets also requires a global approach to supplement national initiatives.

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Declaration

I declare that this thesis is a presentation of original work, and I am the sole author. This work has not previously been presented for a degree or other qualification at this University or elsewhere. All sources are acknowledged as references.

My two supervisors contributed to the data chapters and are included as co-authors on the respective chapters. However, I played the dominant role in all study design, data collection, analysis, interpretation, and writing. Specifically, I led the conceptualisation, fieldwork, data processing and analysis and manuscript development. Professor Lindsay Stringer and Professor Matthew Cotton co-supervised the research. The three data chapters were submitted to academic journals, and two of the manuscripts have been published in Anthropocene Science and Energy Research & Social Science Journals as:

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This doctoral thesis is dedicated to my late Dad, Mr Aigbe Joseph Ogedegbe; my Mom, Mrs Esther Aigbe; my wife, Mrs Patience Godwin-Aigbe; and my children, Michael O. Aigbe, Samuel E. Godwin-Aigbe, and Esther E. Godwin-Aigbe.

Chapter 1

Introduction

1.1. Background to Gas Flaring and Venting

Climate change, caused by increased concentrations of greenhouse gases in the atmosphere, is a critical challenge in need of mitigation. Temperature increases of 2.7°C by the end of the century could occur if annual CO_2 emissions continue to increase from 34Gt in 2020 to 36Gt in 2030 and remain on the same trajectory until 2050 (IEA, 2021; IPCC, 2018; UNFCCC, 2021, 2022). Such emissions would not keep below the 1.5-degree warming countries committed to under the Paris Agreement in 2015.

The energy sector primarily contributes to greenhouse gas emissions through energy production and use (Willyard, 2019). During oil and natural gas development, flaring and venting are commonplace, yet are significant contributors to climate change as they release a substantial amount of greenhouse gases, including CO_2, methane, and black carbon (IEA, 2022; Ismail & Umukoro, 2012; Johnston et al., 2020; Motte et al., 2021). Gas flaring involves burning excess associated natural gases (ANG) extracted along with crude oil and oxygen at the wellhead during oil exploration and development. It can also occur in chemical plants, natural gas processing plants, offshore and gas rigs, oil and gas extraction sites and petroleum refineries (Buzcu-Guven & Harriss, 2014; Elvidge et al., 2009; GGFR/The World Bank, 2023; Willyard, 2019). Process and emergency flares are typically used for emergency relief, overpressure, process upsets, startups, shutdowns, and other safety-related operational purposes. Process flaring usually burns continuously at relatively low flow rates, while emergency flares are sporadic (Johnson et al., 2001) and may also occur at refineries. Venting is the direct release of natural gas into the atmosphere, typically in small amounts. This process is common in the oil and gas industry, often to relieve pressure in pipelines, storage tanks, or other equipment, and can account for up to 10 % of total greenhouse gas emissions in some oil and gas production regions (Pétron et al., 2012). Like flaring, it releases harmful air pollutants, such as volatile organic compounds and nitrogen oxides, impacting air quality and human health (Allen et al., 2013).

While venting and flaring are sometimes necessary as part of safe operations, they are a form of transboundary air pollution. Their environmental and human health impacts are substantial. The effects of gas flaring are felt at local, regional, subregional, and global scales, making it a complex multi-scalar systems issue that needs global attention. In 2021, gas flaring emitted over 400 million tonnes of CO_2, equivalent to the emissions produced by 9 trillion miles of car journeys. Around 10,000 gas flares globally burn at any given time each year – about 140 billion cubic meters, which could meet the electricity demand in Africa for approximately one and a half years (GGFR/The World Bank, 2022; IEA, 2019). In 2019, electricity demand in Africa reached 700-Terawatt hours (TWh) (IEA, 2019). Furthermore, flaring leads to a significant loss of valuable natural gas that could otherwise be used for energy and other productive purposes. With natural gas prices at historical highs, gas flaring results in an enormous economic loss of approximately USD 55 billion per year at a rate of USD 10 per MBtu (IEA, 2022).

1.2. Key Trends in Global Gas Flaring

Most global flaring and venting occur during the upstream production of oil and gas resources. According to the Energy Institute Statistical Review of World Energy (2023), oil production declined by 6.7% (from 94972 thousand barrels per day (Kbbl/d) in 2019 to 88630 (Kbbl/d) in 2020. Correspondingly, global gas flaring decreased by 5.2% (from 156.9 billion cubic meters (Bcm) in 2019 to 148.8 Bcm in 2020). Despite the COVID-19 pandemic, which dampened oil demand, prices, and production between 2019 and 2020, gas flaring was still relatively high (Figure 1.1).

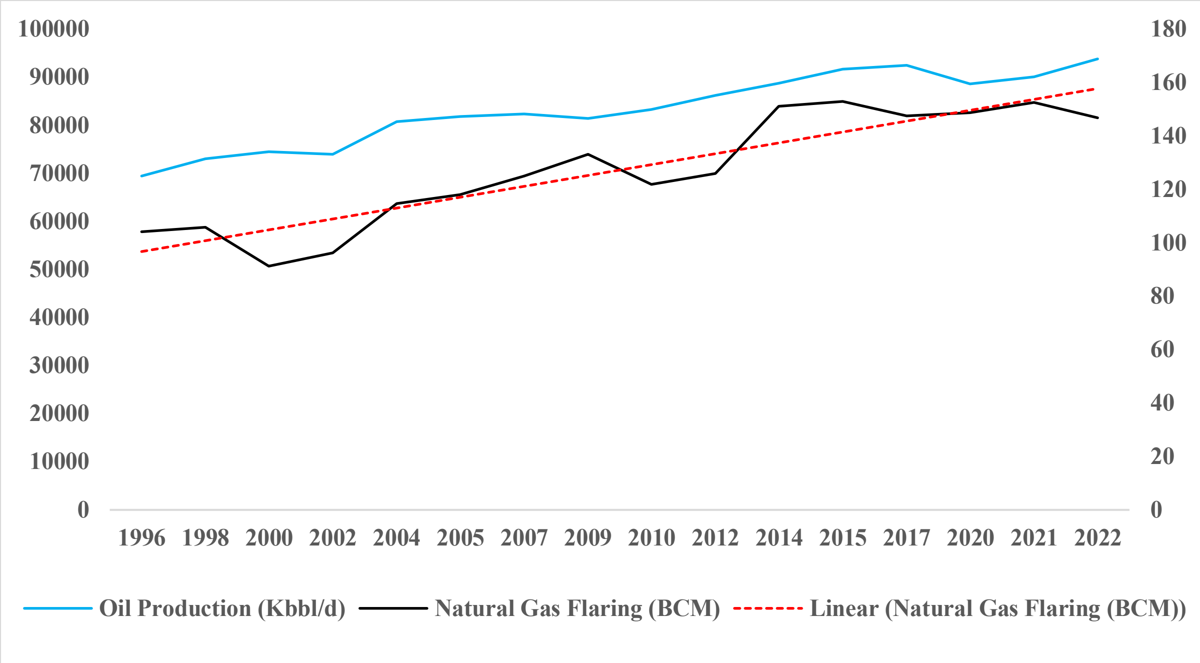


Figure 1.1 Oil production in thousand barrels per day (Kbbl/d) and Gas flaring in billion Cubic Metres (Bcm) 1996-2021 (including information from upstream oil, gas, and LNG plants only). Source: BP (2023); Energy Institute (2023).

Russia, Iraq, Iran, the United States, Algeria, Venezuela, and Nigeria have consistently remained among the seven highest gas-flaring countries. These nations produce 40% of global oil annually, accounting for approximately two-thirds (65%) of global gas flaring (GGFR/The World Bank, 2022). Notwithstanding Colombia not being a significant contributor to overall global flare volumes, the country has impressively reduced flare by 67% between 2012 and 2021. Kazakhstan has achieved a substantial overall flare reduction of 62% during the same period. Although Nigeria has an overall flare reduction of 31%, and the United States has an 8% reduction between 2012 to 2021, there are worrying trends in most countries, resulting in mixed progress towards zero routine flaring globally (GGFR/The World Bank, 2023). For instance, Russia's overall flare between 2012 and 2021 increased from 17.8 Bcm to 26.4 Bcm, a rise of 32.6%. Iran has gradually increased gas flaring, with volumes rising from 17.1 Bcm in 2012 to 18.5 Bcm in 2021, a 7.6% increase. Mexico, despite declining oil production over the last 10 years, has increased flaring between 2012 and 2021 from 1.4 Bcm to 7.8 Bcm, an 82% increase, while Iraq has steadily increased gas flaring, with volumes rising from 11.7 Bcm in 2012 to 17.7 Bcm in 2021, a 33.9% increase (BP Statistical Review, 2023; GGFR/The World Bank, 2023). Though this trend indicates ongoing, conflicting, and controversial ostensible challenges facing these countries, flaring is still a wasteful practice. The United States, for instance, has thousands of individual flare sites which are difficult to connect to a market, while a few high-flaring remote oil fields in East Siberia lack the necessary infrastructure to capture and transport associated gas. These geographical factors have contributed to the ongoing flaring trend (GGFR/The World Bank, 2023).

1.3. Environmental and Health Impacts of Gas Flaring

While the stoichiometry of associated natural gas shows that methane is the dominant component, the combustion of methane leads to the release of CO_2. During flaring, various pollutants like methane (95%), ethane (2.5%), propane (0.2%), butane (0.06%), high alkanes (C_5H_{12}+$C_{10}H_{22}$) (0.02%), nitrogen (1.6%), CO_2 (0.7%), hydrogen sulphide (H_2S), water (H_2O), and other gaseous contaminants, are emitted. Furthermore, poor efficiency in the flare system can lead to incomplete combustion and the release of volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and inorganic contaminants. These can harm human health and the environment (Fawole et al., 2016; Ite & Ibok, 2013; Umukoro & Ismail, 2017).

Gas flaring can exacerbate environmental issues at both local and regional levels. Soot/ black carbon (BC) is produced when biomass, solid fuel, and fossil fuel are incompletely burned (Goldberg, 1985; Koch et al., 2009). Globally, BC emissions are the second or third most important climate forcer, with significant uncertainty surrounding their impact on climate change (Bond et al., 2013; IPCC, 2014; Stohl et al., 2015). It is estimated that global fossil fuel combustion contributes 3 million tons of BC to the atmosphere each year, and gas flaring contributes to the global concentration of BC, with an estimated annual contribution of 260 gigagrams (Gg). However, this only accounts for approximately 0.1% of the total BC contribution from fossil fuel use (Bond et al., 2013). Specifically, gas flare sites, which are often located near villages, produce "soot" that settles on the roofs of nearby buildings. When it rains, this soot gets washed off the roofs and pollutes the soil and water aquifers of the people living nearby (Aghalino, 2009).

Additionally, the release of sulphur dioxide, nitrogen oxides, and other acidic gases during gas flaring can lead to terrestrial acidification, damaging soil, vegetation, and aquatic life (Dung et al., 2008; Motte et al., 2021). Acid rain causes environmental degradation by contaminating soil and water, as well as eroding roofs and buildings. In developing nations like Nigeria, there is a prevalent local and regional issue of environmentally unethical gas flaring that has significantly contributed to the degradation of the region's environment. The concentration of acid in rainwater is notably higher in the Niger Delta region and decreases further away (Ismail & Umukoro, 2012), while a review of the effects of gas flaring on vegetation and water quality resources in Nigeria's Niger Delta region revealed that gas flaring causes changes in water ions, pH, conductivity, and heavy metal concentrations (particularly lead and iron) in rainwater (Seiyaboh & Izah, 2017).

Gas flaring has harmful effects on the surrounding environment, especially on plant growth and wildlife, altering the physical and chemical properties of the soil at the flare sites. Specifically, in South-Eastern Nigeria, the vegetation surrounding waste gas flares is impacted (Isichei & Sanford, 1976). In a study conducted by Odjugo & Osemwenkhae (2009), the impact of gas flaring on maize yield was examined. Their findings indicated that the sand content of the soil, pH, bulk density, air, and soil temperatures increased towards the flare site. As a result, it was recommended that maize should not be cultivated within 2 km of the bund wall of the flare sites to achieve the optimal yield within the Niger Delta where gas flaring is prevalent. Furthermore, the study revealed a correlation between environmental factors resulting from gas flaring and the development of certain illnesses in individuals residing in those areas.

Moreover, flaring causes air pollution that poses health hazards by releasing toxic chemicals like benzene and naphthalene, causing headaches, tremors, irregular heartbeats, cancer, eye, liver, respiratory, and heart diseases, and even strokes (GGFR/The World Bank, 2022; Johnston et al., 2020). Gas flaring can also cause skin cancer and stomach ulcers due to contaminated water (Ite & Ibok, 2013; Soltanieh et al., 2016), and communities near oil and gas locations are at risk of exposure to toxic compounds (Ialongo et al., 2021; Lee et al., 2022). $PM_{2.5}$ particles, which contain a high percentage of BC, have a detrimental effect on human health (Fann et al., 2012; Janssen et al., 2012). When BC is inhaled or when it penetrates the skin and enters the body, it can cause respiratory diseases, cardiovascular issues, and even cancer. In a quasi-experimental design concerning natural gas flaring, respiratory health, and distributional effects, Blundell & Kokoza's (2022) analysis demonstrates a causal connection between the quantity of flared natural gas up to 60 miles upwind from a zip code and the percentage of its population that undergoes a hospital visit related to respiratory issues within a month.

1.4. Governance Arrangements to Reduce the Impacts of gas flaring

Several governance arrangements have been implemented to reduce the impact of gas flaring. However, effective governance requires collaboration between governments, International Oil Companies (IOCs), and civil society organisations. The current governance arrangements for reducing gas flaring include regulatory policies, financial incentives, and technological advancements. Although issues persist in most countries centred around a weak natural gas market, lack of incentive measures, ineffective penalties and fines, and a lack of transparent measurement and reporting (Castelo Branco, Szklo and Schaeffer, 2010; Loe and Ladehaug, 2012; Korppoo, 2018; Rodrigues, 2022; Radhakrishnan, DiCarlo and Orbach, 2023; Shahab-Deljoo et al., 2023; Wen, Xiao and Peng, 2023), incentives such as tax credits, tax breaks and subsidies have been used to encourage companies to reduce their gas flaring, which has led to the development of new technologies such as gas-to-liquids (GTL) and liquefied natural gas (LNG).

At the national level, many countries have developed and implemented policies and regulations to reduce gas flaring. Norway was among the first to introduce regulations requiring operators to meter gas and tax flaring-related CO_2 emissions, resulting in an 80% reduction in gas flaring emissions since the mid-1990s. More than any other OECD country, the United Kingdom reduced flaring by 62% between 1990 and 2020 and has committed to the World Bank's Zero Routine Flaring by 2030 initiative, working with regulators to eliminate this practice. Qatar, Colombia, and Angola have joined the Zero Routine Flaring by 2030 initiative and implemented various projects to reduce gas flaring and increase gas utilisation. Egypt has been working to reduce gas flaring and venting since 2007 through regulatory reforms, technical assistance, and financial incentives. Gabon was the first African country to join the Zero Routine Flaring by 2030 initiative and has developed a national gas master plan to increase gas utilisation for power generation, industrial development, and export. In 2021, Algeria stated that it would reduce flare gas volumes to less than 1% by the end of the year. Although this target presumably was the volume of the total associated gas, not the total natural gas produced, the change in flare gas volumes between 2015 and 2021 was -11%, a 2% reduction which exceeded its pledge (GGFR/The World Bank, 2023). Angola has set a similar target of reducing flaring to 5% by 2025, as has Tanzania. Each of these countries has pledged to be a part of the World Bank's Zero Routine Flaring by 2030 Initiative (GGFR/The World Bank, 2022b, 2022a, 2022d, 2023).

Nigeria, one of the largest gas flaring countries globally, committed to signing the United Nations Agreement on Zero Routine Gas Flaring by 2030 and has several initiatives to reduce flaring (GGFR/The World Bank, 2022b, 2022a, 2022d, 2023a). Nigeria's Flare Gas (Prevention of Waste and Pollution) Regulations 2018 required oil companies to eliminate routine gas flaring by 2020 (despite that, this was not achieved). Also, Nigeria has established the National Gas Flare Commercialization Program (NGFCP), which aims to provide incentives for oil companies to reduce flaring and promote the use of natural gas. Issues with governance arrangements, regulatory compliance, ineffective gas flaring policies and policy conflicts between economic development and environmental protection priorities, inconsistent regulations, lack of transparency, and incentives for flaring mean progress has nevertheless been slow (Agbonifo, 2016; Aigbe, Cotton, et al., 2023; Aigbe, Stringer, et al., 2023; Babalola & Olawuyi, 2022; Bello, 2023; Buzcu-Guven & Harriss, 2014; Fawole et al., 2016a; Mrabure & Ohimor, 2020; Olujobi & Olusola-Olujobi, 2020; PFC Energy/The World Bank, 2007; Svensson, 2005; Zhizhin et al., 2021). The United States has also introduced the Oil and Gas Methane Rule, which requires companies to reduce their operations' methane emissions and capture and end all routine gas flaring by 2025. Gas flaring has been effectively reduced in some states in the United States through state-level governance arrangements. In North Dakota, for example, regulations have led to a substantial decrease in gas flaring in 2021. This reduction can be attributed to operators capturing 92.5% of produced natural gas– exceeding the state's goal of capturing 91% of the natural gas produced (EIA, 2023). However, in Texas, the involvement and influence of powerful state and industry actors in gas flaring policies and implementation processes have resulted in weak policy implementation (Willyard, 2019).

At the regional level, the Methane Strategy of the European Union aims to reduce methane emissions by 30% while ending the routine practice of gas flaring by 2030 (GGFR/The World Bank, 2022b, 2022a). The Global Gas Flaring Reduction Partnership (GGFR) initiative, the Zero Routine Flaring by 2030 initiative, and the Clean Development Mechanism (CDM) are the dominant international-level mechanisms. The GGFR, launched in 2002 (GGFR/The World Bank, 2023), and provides impetus to enable flare reduction programs globally (Cutler et al., 2018; Okafor & Aniche, 2016). The Zero Routine Flaring by 2030 initiative, launched by the United Nations in 2015, calls for eliminating routine gas flaring by 2030 and has been endorsed by several nations and oil and gas companies (GGFR/The World Bank, 2023). The initiative recognises that collaboration between governments, industries, and civil society is required. Another key governance arrangement at the international level is the United Nations

Framework Convention on Climate Change (UNFCCC). The UNFCCC is an international treaty that aims to prevent dangerous levels of climate change by reducing greenhouse gas emissions and supporting adaptation. The Convention supports the reduction of gas flaring through its CDM and allows developing countries to earn carbon credits by implementing emission reduction projects, including those that reduce flaring (Gillenwater & Seres, 2012; Subbarao & Lloyd, 2011; UNFCCC, 2021). Although global gas flaring slightly decreased in 2022, from 144 Bcm in 2021 to 139 Bcm, the decline was mainly due to the cessation of Russian oil and gas imports associated with Russia's invasion of Ukraine (GGFR/The World Bank, 2023). While the initiatives at national and international levels to reduce gas flaring are a positive step forward, further action is necessary to eradicate this issue on a global scale completely.

1.5. Natural Gas as a Transition or Bridge Fuel to Sustainability

Gas flaring, a complex global environmental problem, can exacerbate climate change impacts. However, if utilised, it could also accelerate low-carbon energy transitions in the short term. Transitioning to a low-carbon energy system and reducing gas flaring poses dual challenges: reducing emissions to achieve a net-zero routine flaring target and providing access to energy to accelerate the transition. Although renewable energy solutions dominate the current discourse on transitioning to a decarbonised energy system, renewable energy must overcome challenges in generating stable and secure energy before replacing natural gas as a long-term solution (Smil, 2015). Combining natural gas with renewable energy is an option to promote innovation, technology diversity, and energy security (Safari et al., 2019). While some studies indicate that substituting natural gas with coal and oil can significantly reduce greenhouse gas emissions in the short term, its long-term effects may delay the transition to renewable energies. Although natural gas emits about half the amount of CO_2 emissions compared to other fossil fuels with almost the same calorific value (Smil, 2015; Stephenson et al., 2012), it is considered a transition fuel to temporarily reduce greenhouse gas emissions until more sustainable technologies are developed (Gürsan & de Gooyert, 2021). Without leveraging a bridge fuel or transitory fuel, the transition to a low-carbon system may be challenging to achieve, necessitating temporary investment in natural gas, although natural gas is currently considered a legacy or sunset industry (Gürsan & de Gooyert, 2021; Perrons, 2021).

Natural gas as a legacy or sunset industry has been contentious in the energy sector, but some have argued that natural gas is already a legacy industry (Perrons, 2021), with peak usage in the past and a limited future as renewable energy grows. Others view it as a sunset industry with a gradual decline as the world moves away from fossil fuels in the coming years. Although natural gas is a finite resource (Chermak & Patrick, 1995; MacKenzie, 1998), and its extraction and use have significant environmental impacts, including greenhouse gas emissions and water pollution, it is currently a vital component of the energy mix in many countries, providing a reliable and affordable energy source. As we work towards developing renewable energy systems for the future, there is a need to also focus on reducing emissions from our current legacy energy sources, which some argue will remain in use for the foreseeable future, at least in the short- to medium-term future (Perrons, 2021). It is, therefore, essential to acknowledge the role natural gas will continue to play in our energy mix for the foreseeable future, particularly as a transitional fuel to support the energy transition.

In this context, using natural gas from gas flaring and venting as a transition fuel involves replacing high-content fossil fuels such as coal and oil with otherwise flared gas. Despite the global dominance of coal and oil in electricity generation (Figure 1.2), natural gas can be combined with renewable technologies to offset intermittent electricity outputs and provide an uninterrupted energy supply during peak hours while remaining flexible during irregular cycles (Ahmed & Cameron, 2014; Arent et al., 2015; Colombo et al., 2016; van Floris, 2010, 2011).

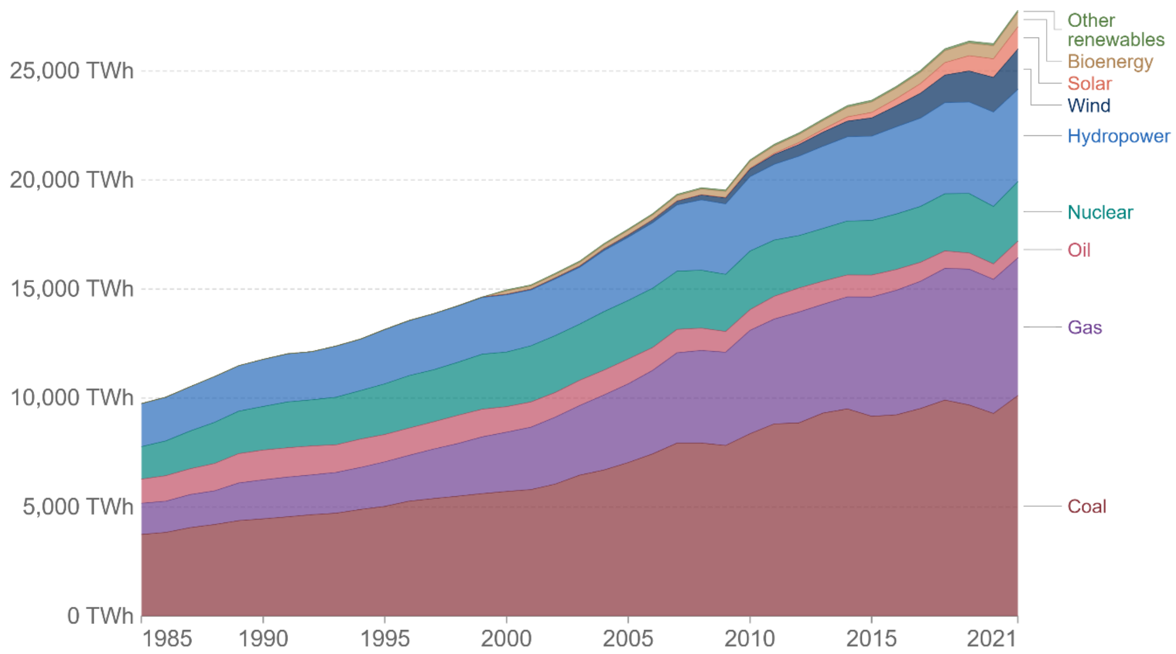


Figure 1.2. Electricity production share by fuel source in 2021. Source: OurWorldInData, (2022). The figure shows the time frame from 1985 to 2021 on the horizontal axis, and the unit of measurement for the vertical axis is terawatt/hour.

While oil and gas development has dramatically boosted the economy of many countries (Ayuba, 2012), the petroleum industry remains a significant contributor to emissions (Bagheri, 2019). Despite climate change, oil and gas will continue to be a crucial component of the world's energy mix for the foreseeable future. By 2030, natural gas is predicted to surpass coal as the second-largest energy source globally (IEA, 2019). Though natural gas remains crucial and offers short-term benefits in reducing emissions, it has also been shown that without carbon capture and storage (CCS), the future role of natural gas might be a bridge to nowhere (McGlade et al., 2018).

Even though natural gas can be an important player in the energy transition, natural gas and flaring resulting from exploration, extraction, and use pose justice challenges among communities hosting gas flaring activity. These issues include equal access to energy generation from natural gas, equitable access to green spaces, compensation for host communities, exposure to natural disasters and climate change impacts due to flaring (Aigbe et al., 2023), and the spatial distribution of gas flaring pollution risks including transboundary pollution (Altamirano-Cabrera et al., 2013; Millimet, 2013; Varkkey, 2019). If natural gas is to play a significant role in the energy transition, stakeholder support and institutional solutions are necessary to ensure a just, sustainable, and equitable governance framework that guarantees progress and legitimacy.

1.6. Researching Gas Flaring Governance

Gas flaring creates local and transboundary pollution, but its management faces various policy and regulatory challenges encompassing complex multi-scalar systems at different levels. While fossil fuel resources add greenhouse gases to the atmosphere, exacerbating climate change, they also impact people at different levels, from local host communities to national and global levels, necessitating targeted policy actions to enhance regulatory compatibility and institutional synergy across different levels of governance. The World Bank and United Nations' target to end routine gas flaring by 2030 requires a coordinated effort between stakeholders and a proper understanding of different levels of gas flaring governance and how energy justice principles can be incorporated.

Many environmental resources, including natural gas and flaring, are governed by a complex web of multilevel or overlapping institutions, creating a complex regulatory landscape. Thus, environmental problems, including global gas flaring, are complex, socially constructed, and require careful consideration from a multi-scalar perspective (Jasanoff et al., 1998). Gas flaring governance refers to the policies and regulations governing natural gas flaring during oil production. These policies and regulations are designed to minimise the environmental impact of gas flaring, while energy justice principles ensure that the benefits and burdens of energy systems are distributed equitably among all stakeholders. Globally, there is a need for strong governance of gas flaring, including international standards and regulations and financial and technical assistance to those countries struggling to manage gas flaring. At the national level, there is a need for effective federal laws and regulations alongside institutions responsible for enforcing these laws and regulations. At the local level, there is a need for robust community-based governance of gas flaring through the involvement of local communities in decision-making processes and providing compensation and other benefits to communities affected by gas flaring. More specifically, it requires consideration of the role of multilevel governance (MLG), policy coherence, good governance and energy justice through policies and regulations across scales to promote sustainable energy production and consumption. Such a multi-scalar perspective involves understanding the interplay between local, regional, national, and international actors and institutions in the global gas flaring processes.

The practice of gas flaring raises important questions about policy and governance (Agbonifo, 2016; Babalola & Olawuyi, 2022; Bello, 2023; Buzcu-Guven & Harriss, 2014; Mrabure & Ohimor, 2020; Svensson, 2005), as well as local and global justice (Babalola & Olawuyi, 2022; Cushing et al., 2021; Franklin et al., 2019; Johnston et al., 2019, 2020). The externalities caused by greenhouse gas emissions, pollution, and health impacts have global implications and affect human rights and values (Aigbe et al., 2023; Fox & Ward, 2008). However, there is a lack of a comprehensive approach to the energy system, including the natural gas system from its extraction to waste disposal (gas flaring), requiring a whole system approach (Gagnon et al., 2002; Jenkins et al., 2014; Martiskainen et al., 2021). Since the framing and conceptualisation of environmental issues can significantly impact the interests of diverse groups, adopting a whole systems approach that incorporates the concepts of MLG, policy coherence, good governance, and energy justice is crucial. This approach also acknowledges the various levels of governance involved in energy policymaking and each group's unique challenges, ultimately leading to a more equitable and sustainable energy future. Additionally, to ensure efficient and inclusive gas flaring policies and processes, it is essential to uniformly embed and integrate them across spatial scales and different levels. Chapter 2, addressing objective 1 of this thesis, critically reviews the literature on a whole systems approach, multilevel governance and policy coherence in complex governance systems, good governance, and energy justice as relevant approaches in abating global gas flaring.

As most oil and gas-producing nations, especially those in the global south, have centralised governments and authoritarian leadership with strict personal rule, achieving social justice for the poorest communities in these regions that rely on fossil fuel production is difficult (Ikpe, 2000; Leonard & Straus, 2003; Takehiko, 2010; Yagboyaju & Akinola, 2019; Yakubu, 2018). Despite some attempts at collective legislative action to address issues like gas flaring, the impact on local host communities has been minimal or non-existent (Dartey-Baah et al., 2014; Donwa et al., 2015; Husted & Blanchard, 2018; Idemudia et al., 2010; Ncala, 2016; Watts, 2004). As a result, many oil and gas-producing areas still struggle with low levels of economic development. In many jurisdictions, conflicts arise due to a lack of shared understanding among formal, national, and local community governance structures and processes regarding the management of gas flaring. This is largely due to government institutions' differing forms and functions. Navigating the complex landscape of political and institutional structures, policies, and socio-economic factors within a tightly controlled federal system and personal rule demands MLG and policy coherence frameworks to analyse the relationships between actor perspectives and institutional and policy frameworks across different policy sectors. This need is addressed in chapter 3 by focusing on Nigeria as a case study, addressing objective 2 of this thesis.

Gas flaring concerns global externalities from associated greenhouse gas emissions, including local and global environmental injustice. The issue of gas flaring governance is crucial for local and global energy justice under an empirical ethics stance (Molewijk et al., 2004). To ensure justice in energy and global gas flaring, it is imperative to conduct social science research to understand the normative stakeholder viewpoints regarding gas flaring justice and the impact on the communities affected and to gain insight into policy actions across the different country contexts in which flaring occurs. Although gas flaring has been the subject of many social science case studies (Babalola & Olawuyi, 2022; Cushing et al., 2021a, 2021b; Franklin et al., 2019; Iguh, 2016; Johnston et al., 2019, 2020; Okeagu et al., 2006), they have mainly been place-based. These studies have highlighted the importance of fairness, rights, well-being, and community involvement in the decision-making process to ensure equitable outcomes. Addressing justice and inequality concerns that may arise as authorities aim to enhance gas resources' efficiency or phase them out to align with energy transition objectives is crucial. Furthermore, the benefits and burden of natural gas and flaring should extend across levels, particularly to local host communities, through measures such as subsidised electricity, strengthening community resource rights, empowerment of local institutions, and improved income through benefit-sharing. However, the absence of a fair and equitable benefit-sharing mechanism, poor governance, inadequate information about the impact of gas flaring on local host communities, and insufficient participation of the communities in the design, implementation, and monitoring of natural gas exploration and production programmes at the local, national, and global levels, hinder the effectiveness of efforts to mitigate gas flaring globally. This is addressed in chapter 4 under objective 3 of this thesis.

There are many global challenges to eliminating gas flaring, such as carbon-intensive infrastructure, lock-in conditions by industrial nations (Mattauch et al., 2015; Unruh, 2000, 2019; Unruh & Carrillo-Hermosilla, 2006; Ylä-Anttila et al., 2018), a lack of global environmental and flaring policies to control transboundary air pollution (Torre et al., 2021; Varkkey, 2019), and lack of appropriate flaring policies and regulations. Outdated legal and regulatory provisions also make it difficult to monitor and enforce existing regulations (Buzcu-Guven & Harriss, 2014; Korppoo, 2018; Nelson, 2018; Olujobi, 2020; Olujobi et al., 2022; Olujobi & Olusola-Olujobi, 2020; Radhakrishnan et al., 2023). In addition, there have been failures in the design and implementation of gas flaring policies, incoherent legislative and regulatory frameworks, and a lack of transparency in reporting and disclosing statistical data (Agbonifo, 2016; Babalola & Olawuyi, 2022; Bello, 2023; Fawole et al., 2016; Gerner et al., 2004; Mrabure & Ohimor, 2020; Svensson, 2005; Zhizhin et al., 2021). There are also challenges related to weak natural gas markets and ineffective penalties and fines (Castelo Branco et al., 2010; Korppoo, 2018; Wen et al., 2023). As environmental and flaring policies in one country are influenced by the policy choices of other nations due to transboundary air pollution, this can also affect the choices of other jurisdictions. This situation necessitates consistent global policies that can lead to more ambitious and equitable outcomes (Millimet, 2013). While gas flaring constitutes transboundary pollution, the policies, and regulations to reduce flaring have been addressed through country-level arrangements and voluntary agreements within the INDCs (UNFCCC, 2021, 2022). Literature on comparative politics of climate policy suggests cross-national variations in instrument selection by governments to reduce emissions, including gas flaring (Harrison & Sundstrom, 2010; Lachapelle & Paterson, 2013; Rabe, 2007; Selin & VanDeveer, 2009), while efforts to reduce flaring have been hindered due to the lack of coherent environmental policies and regulations (Altamirano-Cabrera et al., 2013; Ialongo et al., 2021; Loe & Ladehaug, 2012; Rodrigues, 2022; Shahab-Deljoo et al., 2023; Soltanieh et al., 2016; Wen et al., 2023), even though consistent global policies supported by national policies can achieve more ambitious and equitable outcomes than country-level or national policies alone. There thus remains a need for targeted policy actions to improve regulatory compatibility and institutional synergy across global, national, sub-national, and local levels. This is addressed in chapter 5 under objective 4 of this thesis.

Specifically, the theoretical concept of the energy system, including the natural gas system from its extraction to waste disposal (global gas flaring), needs to be reconceptualised and enhanced within a whole system approach. Additionally, there are conflicts due to a lack of shared understanding among formal, national, and local community governance regarding the management of gas flaring in many jurisdictions particularly in the Global South, attributed to centralised governments and authoritarian leadership with strict personal rule. There is a need to analyse governance systems and assess the policy coherence across gas flaring and energy sectors to navigate the complex political and institutional structures, policies, and socio-economic factors. There are several injustices around global gas flaring, and understanding stakeholder perspectives on gas flaring justice, including the importance of fairness, rights, well-being, and community involvement in decision-making, is crucial for developing equitable policies and regulations to address the impact on affected communities. Furthermore, emergent perspectives on energy justice and global gas flaring are required to develop fair and inclusive gas flaring policies and regulations. Gas flaring constitutes transboundary pollution addressed through country-level arrangements and voluntary agreements within the INDCs. Also, as there are cross-national variations in instrument selection by governments to reduce emissions, including gas flaring, efforts to reduce flaring have been hindered due to the lack of coherent environmental policies and regulations. There is a need to evaluate preferences for various policy and regulatory options and determine the most optimised policies and regulations and effective approach to stimulate the elimination of routine gas flaring by 2030 and achieve net zero emissions by 2050 while addressing any unfair implementation of policies and regulations.

1.7. Aim, objectives, and Thesis Structure.

This thesis aims to integrate multilevel governance, policy coherence, good governance, and energy justice to analyse global gas flaring issues and optimise policy solutions and regulations to stimulate progress towards targets of zero routine flaring by 2030 and net zero emissions by 2050. It considers options that encompass fairness and equity while supporting the energy transition. Overall, the thesis consists of six chapters. Chapter 1 provides the background to global gas flaring and venting, including the key trends, environmental and health impacts, and current governance arrangements. The chapter also introduces natural gas as a bridge to sustainability and highlights the research problem and gaps, setting the aims and objectives for the thesis.

The thesis uses mixed methods to achieve four objectives:

a) Objective 1: To reconceptualise and enhance theories linked to global gas flaring by proposing a new perspective on global gas flaring issues. This is addressed in chapter 2, which reviews and analyses the literature on multilevel governance and policy coherence in complex governance systems involving multiple levels and energy justice principles. It identifies the strengths of the approach, highlighting the theoretical importance of abating global gas flaring and answering the specific research question:

    i. How do multilevel governance, policy coherence, good governance, and energy justice fit within a systems approach in the conceptualisation of global gas flaring?

b) Objective 2: To analyse Nigeria's multilevel governance system and assess the policy coherence across gas flaring and energy sectors. This is addressed in chapter 3, which provides an empirical analysis of gas flaring in Nigeria, analysing the country's gas flaring policy and governance. Nigeria's case is critical since the continued operation of the oil and gas industry is central to the country's economic and social development. Specifically, this chapter answers the following research questions:
    i. Who are the main actors involved in Nigeria's multilevel governance system pertaining to oil and gas governance?
    ii. To what extent are gas flaring awareness and policy coherence across gas and energy domains?
    iii. How can the implications for progress towards Nigeria's national intended contribution and national policy on climate change mitigation be assessed?
c) Objective 3: To analyse the emergent perspectives on energy justice and global gas flaring and evaluate how agreement and disagreement among these views contribute to developing equitable and inclusive gas flaring policies and regulations. This is addressed in chapter 4, which provides an empirical ethics analysis of stakeholder perspectives on global gas flaring and energy justice. Specifically, this chapter answers the following research questions:
    i. What are the emergent perspectives on energy justice and global gas flaring governance?
    ii. How can consensus and conflict between competing perspectives help to inform fair and inclusive gas flaring policies?
d) Objective 4: To evaluate stakeholder preferences for different policies and regulatory options, determining the most optimised and effective to help eliminate routine gas-flaring by 2030 and achieve net zero emissions by 2050 whilst addressing good governance, justice, and fair implementation. This is addressed in chapter 5, which specifically answers the following research questions:
    i. What are the key criteria and sub-criteria, and alternative gas flaring policies and regulatory frameworks that can help meet the 2030 zero routine flaring target?
    ii. How can these criteria, sub-criteria, and alternative policy scenarios be prioritised, selected, and benchmarked to stimulate flaring reduction actions?

iii. What are the optimal gas flaring policies/regulatory framework criteria and sub-criteria, presenting the best alternative policy scenario to stimulate flaring reduction actions?

Chapters 3 to 5 are the three central data and results chapters written in the style of scientific papers, contributing to the overall thesis aim while addressing the specific objectives outlined above. While this format has resulted in some repetition of rationale and method between chapters, each chapter can be understood as a stand-alone contribution, as well as contributing to the overall aim. The style of each chapter follows the respective journal's formatting guidelines. The thesis concludes in chapter 6 by reflecting on the insights from the three results chapters, discussing the advances and policy relevance, implications for policies and practice and recommendations, and the scope for further research.

1.8. Research Design

This sub-section introduces a conceptual approach, framed as a systems approach to global gas flaring issues, incorporating governance, policies, and energy justice issues. It then justifies the three analytical case studies. It is grounded in an interactive framework comprising separate research components that interact to achieve the overall research aim (see Table 1.1 and Figure 1.3).

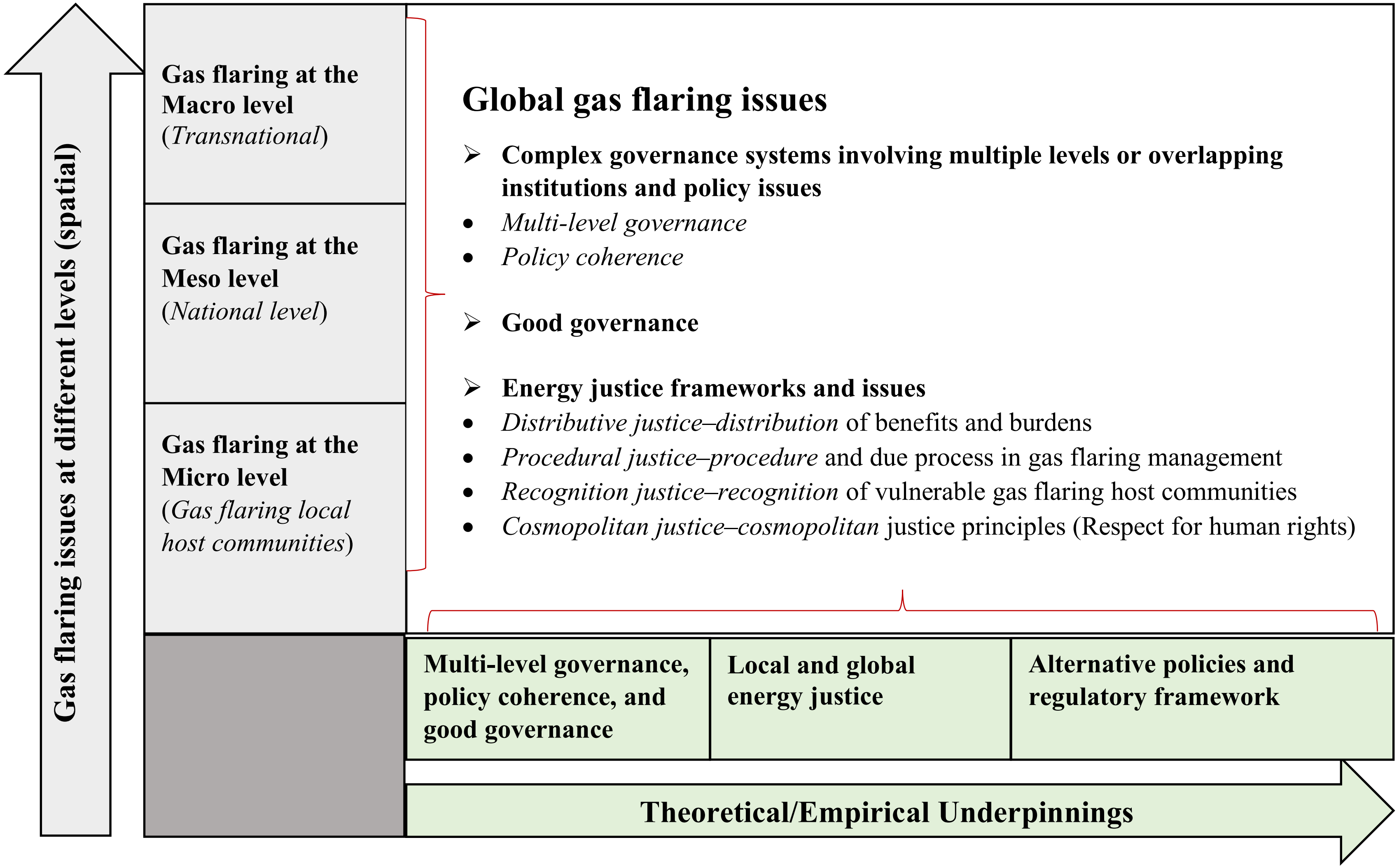


Figure 1.3. The conceptual framework for global gas flaring used in this thesis.

1.8.1. Case Study Selection

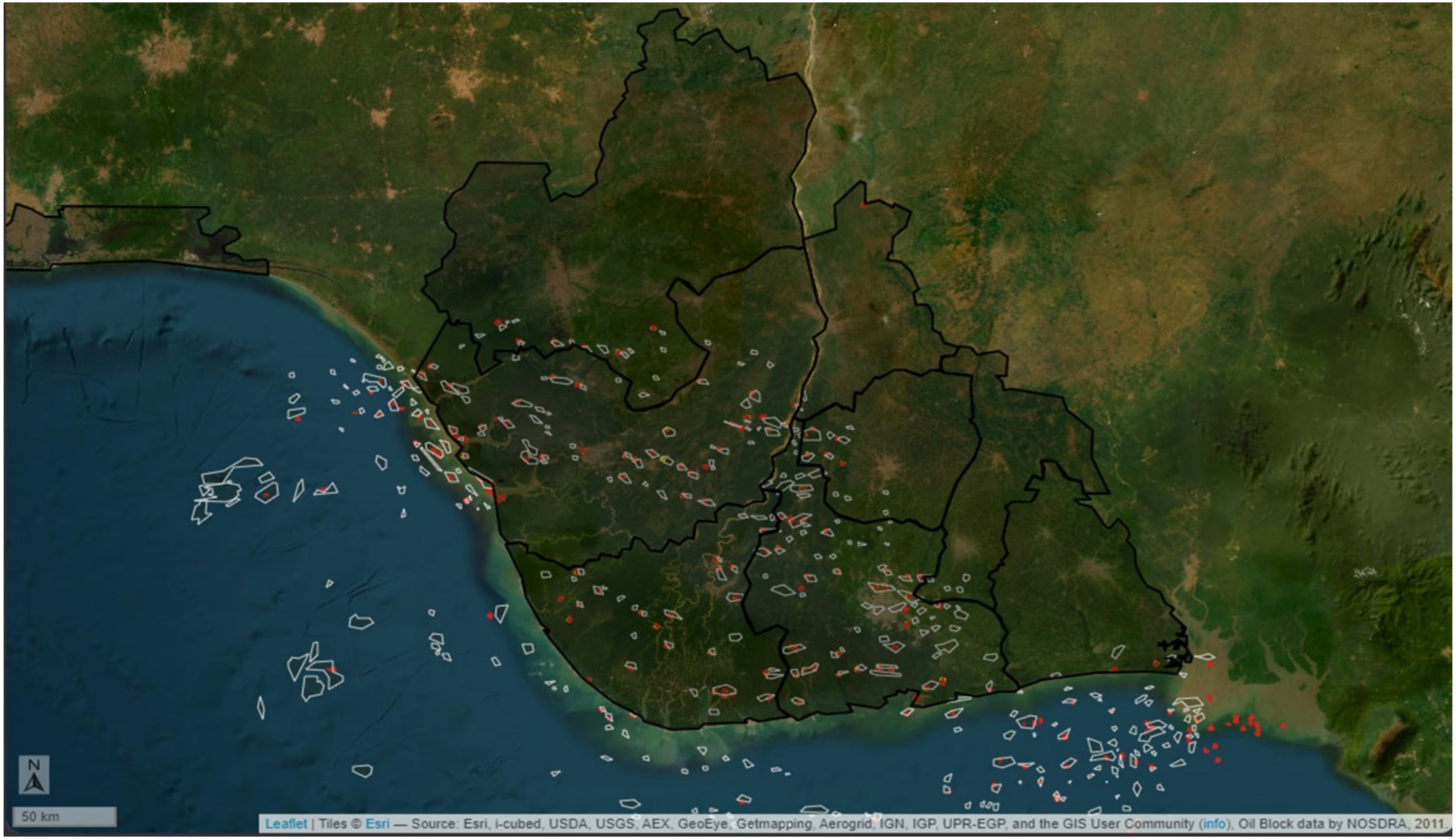
Debates on gas flaring cannot be viewed independently from country-level developments but need to be analysed within a systems approach incorporating local, national, and global trends. The scope of analysis and the implemented research design included different scales of gas flaring issues- crucial for understanding the need for strong national, regional, and global participation and leadership in the gas flaring reduction process. It also accommodated COVID-19 travel restrictions and social distancing impacts that required the overall project to be reshaped from its original focus.

Gas flaring is the object of analysis of the thesis, set within multiple scales and a case study approach. Taking a case study approach was useful because case studies facilitate the search for concepts and categories, which helps to understand a particular phenomenon where the difference between phenomenon and context needs to be clarified (Yin, 1994). With a multi-scalar framework approach established, this thesis sought to select a strong example from the world's ten most prolific gas-flaring countries, i.e., a country where gas flaring issues are local and/or national. Thus, Nigeria was selected as a case study to explore the governance and policies of gas flaring and the unequal power relations in the development, deployment, and local responses to gas flaring issues locally and nationally.

Nigeria lies between latitudes 5^0 South and 13^0 North and longitudes 6^0 West and 8^0 East and has an area of 923,768 km^2 and a population of over 216.7 million (NPC, 2023; UNPF, 2022). The country has five main agroecological zones (AEZ) (Adetuniji et al., 2014; Akanni Oluyole, 2010; Udoh et al., 2000). Nigeria is the largest oil-producing country in Africa, with 37.0 billion barrels of proven crude oil and an estimated 200.4 trillion cubic feet (Tcf) or 5674.70 Bcm of proven natural gas reserves, positioning the country as the largest natural gas reserve on the continent and the world's fifth–largest exporter of liquefied natural gas (LNG) in 2018 (EIA, 2020). Fossil fuels account for over 80% of government revenues, 95% of export receipts, and 90% of foreign exchange earnings (Watts, 2004; Uwakonye, Osho and Anucha, 2006; Oladele and Abdul-Azeez, 2013). Although the Nigerian Government's utilisation of natural gas resources is a core aspect of its administrative operations, a significant volume of Nigeria's gross natural gas production is either reinjected or flared (EIA, 2020).

The Niger Delta region of Nigeria, where gas flaring occurs, is located within nine coastal southern Nigerian states (Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo, Rivers, and Lagos) (Figures 1.4, 1.5 and 1.6). The Nigerian case can be regarded as a critical leading case study because the continued operation of the oil and gas industry is central to the country's economic and social development strategy. Accordingly, chapter 4 of this thesis focuses on Nigeria.

Figure 1.4. Map of Nigeria, including the 36 states. Source: (WorldAtlas, 2023).



1.5. Nigeria gas flare tracker: Geographic areas where gas flaring is detected (States, Local Government Areas), oilfields/blocks in individual flaring sites or onshore/offshore (white marks), gas flare locations (red dots), estimated population living 2 km from flare locations (yellow spots)—source: Nigeria gas flare tracker (2023).

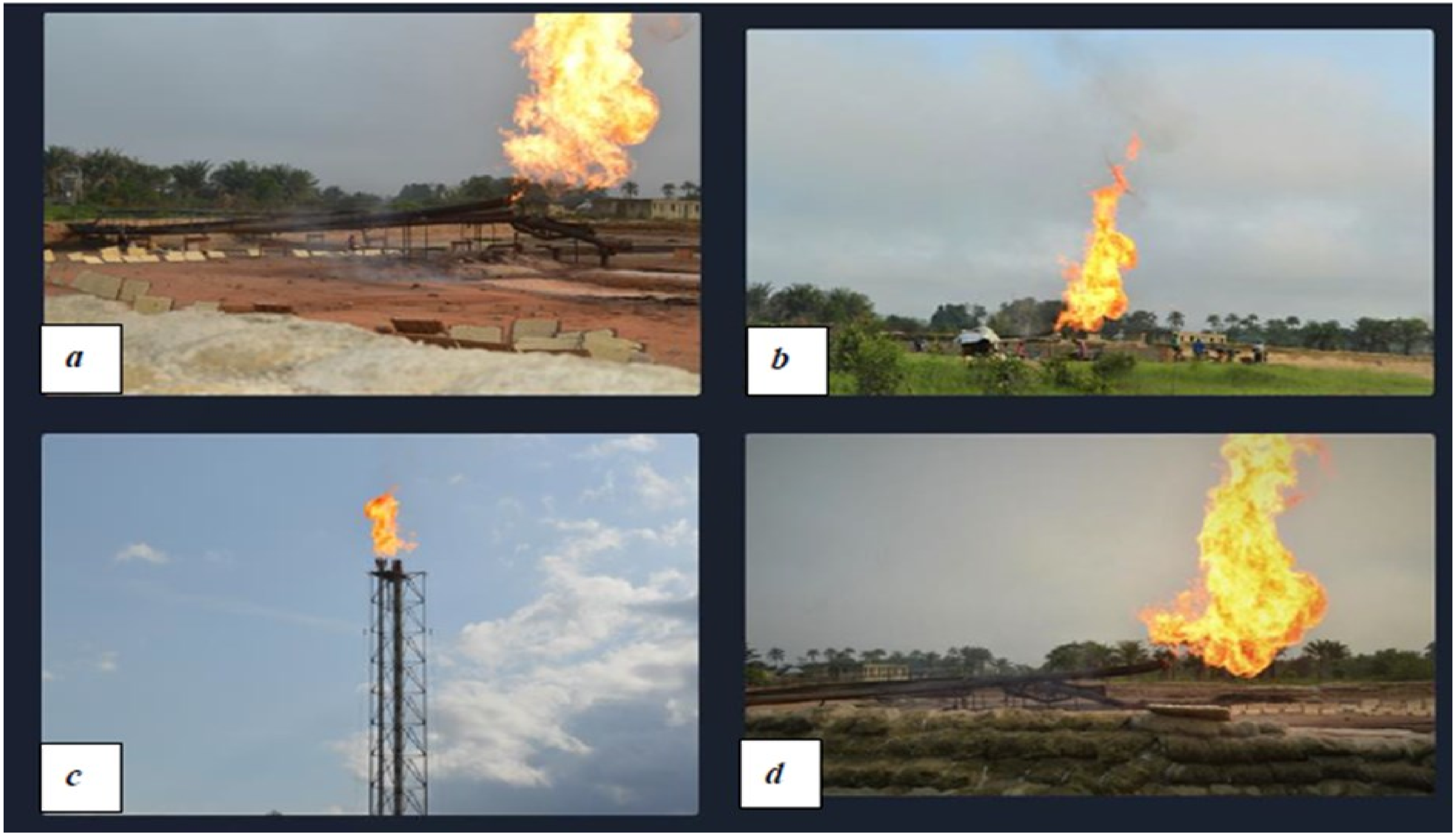


Figure 1.6 Gas flaring. Images a b and d show gas flaring near people's homes while image c shows flare stack in a local host community, Otu Jeremi Community, Ughelli, Delta State, Nigeria—pictures by ThankGod Okorisha.

The Nigeria case was strategically selected due to the challenges the country still faces resulting from the political dynamics of personal rule and the lack of political will to implement gas flaring reduction policies, social marginalisation, equity, and rent-seeking issues. Literature attributes the lack of political will to end gas flaring to the continued economic interest in fossil fuel extractivism from the Nigeria Federal Government and other stakeholders (Akinola, 2018; Iornumbe, 2019; Benson, 2020; Olujobi and Olusola-Olujobi, 2020). Accordingly, the Nigerian federal government's strict political control over ministries/institutions and parastatal agencies allows the federal capital territory to position the Niger Delta region as a sacrifice zone (De Souza, 2021; Ogwu, 2012; Unah & Iruoma, 2021) to meet other national policy as well as personal and partisan policy goals. Additionally, there is a persistent lack of transparency, industry accountability and revenue accumulation by powerful groups or individuals, which further raises questions concerning the political will to cap gas flaring (Hasan & Perot, 2021).

While oil and gas activities in the Niger Delta region of Nigeria have been and are still being run as an enclave within the Nigerian state, gas flaring within enclave economies alters the structure of host communities' job opportunities. IOCs often export labour as expatriates to the enclave regions, exacerbating rent-seeking and corruption and altering the regulatory structure in countries with a unitary system or low regulatory compliance (Ackah-Baidoo, 2012; Symons, 2016). The relationship between host community benefits through job creation and the extractive nature of capital resource flows through enclaves of migrant labour highlights broader distributive global justice concerns within oil and gas supply chains, and this is one of the key concerns that necessitated the Nigerian gas flaring case selection as part of this research. Furthermore, equity issues and social marginalisation are linked to ineffective gas flaring policies, governance structures and incoherent policies, resulting in weak policy implementation.

From a research design perspective, the case study was chosen following Yin's (2009) argument that a case study should be considered when the focus of the research or part of the study is to answer "how" and "why" questions or when the behaviour of those involved in the study cannot be manipulated; or when a study or part of the study want to cover contextual conditions because they are relevant to the studied event; or the boundaries are not clear between the event and the context. As there is a strong link between economics, environmental and social conditions, how the national context of gas flaring influences the lives of people in gas-flaring local host communities or conserves nature, the first analytical chapter (Chapter 3) considers a case study approach as one of the entry points of analysis. Through the case study approach, research objective 2 seeks to obtain an in-depth, multi-faceted exploration of complex issues around gas flaring issues in its natural, real-life context (Crowe et al., 2011) and of the way both the local host communities and the nation at large perceive and manage the impacts of gas flaring and its processes. This is achieved through an in-depth focus on MLG, policies, and justice at the local and national scale within a multi-scalar framework approach.

1.8.2. Thesis Logical Framework

This section provides a synopsis of the logical framework showing the methods used in realising the research objectives. The following approaches/methods of data collection (Table 1.1) enabled the identification of the gap and, advanced the evaluation of preferences for various policy and regulatory options and determined the most optimised policies and regulations and effective approach to stimulate the elimination of routine gas flaring by 2030 and achieve net zero emissions by 2050.

Table 1.1. Methods table showing the link between research questions and methods to realise research objectives.

Research Objective	**Research Question**	**Methods and Sampling**	**Research Strategy**	**Data Analysis**	**Chapter/Publication Title**
(1) To reconceptualise and enhance theories linked to global gas flaring by proposing a new perspective on global gas flaring issues.	(i) How do multilevel governance, policy coherence, good governance, and energy justice fit within a systems approach in the conceptualisation of global gas flaring?	Literature review. No restrictions on the publication year.	A literature review selected across sectors was conducted to construct the theoretical framework in which this thesis was developed.	Thematic analysis.	Whole systems approach to global gas flaring: Integrating multilevel governance, policy coherence, good governance, and energy justice *Chapter 2*.
(2) To analyse Nigeria's multilevel governance system and policy coherence across gas flaring and energy sectors.	(i) Who are the main actors involved in Nigeria's multilevel governance system pertaining to oil and gas governance? (ii) To what extent are gas flaring awareness and policy coherence across gas and energy domains? (iii) How can the implications for progress towards Nigeria's national intended contribution and national policy	Literature review, Semi-structured interviews, and expert survey. Purposive-snowball sampling techniques.	Qualitative Document Analysis (QDA) to undertake a horizontal-level policy coherence analysis of gas flaring at the local/national level to identify the principal key actors involved in such policies, what informs the implementation of policies in a complex governance structure as well as understand the possible environmental and societal implications of the approval of those policies.	Content Analysis and Qualitative Document Analysis (QDA).	Gas flaring in Nigeria: A Multilevel Governance and policy coherence analysis, published in *Anthropocene Science Journal.*

	on climate change mitigation be assessed?				
(3) To analyse the emergent perspectives on energy justice and global gas flaring and evaluate how agreement and disagreement among these views contribute to developing equitable and inclusive gas flaring policies and regulations.	(i) What are the emergent perspectives on energy justice and global gas flaring governance? (ii) How can consensus and conflict between competing perspectives help to inform fair and inclusive gas flaring policies?	Literature review, Q-method survey, and exit interviews. Purposive-snowball sampling techniques participants.	The Q-method approach, a mixed-method social research approach that combines factor analysis with qualitative interpretation to elicit factors that correlate to scores assigned to a set of pre-defined statements, was used to explore respondents' subjective attitudinal perspectives to establish conventional viewpoints around global gas flaring and energy justice issues.	Thematic analysis, Nvivo, Q-method analysis.	Global gas flaring and energy justice: An empirical ethics analysis of stakeholder perspectives, published in *Energy Research & Social Science Journal.*
(4) To evaluate stakeholder preferences for different policies and regulatory options, determining the most optimised and effective to help eliminate routine gas-flaring by 2030 and achieve net zero	(i) What are the key criteria, sub-criteria, and alternative gas flaring policies and regulatory frameworks that can help meet the 2030 zero routine flaring targets?	Literature review, expert/knowledge survey Purposive-snowball sampling techniques.	The AHP and G-TOPSIS methodology was employed to address the barriers to gas flaring policy and regulatory action. It was used to evaluate preferences for various policy and regulatory options and determine the most optimised policies and	Analytical hierarchy process (AHP) and G-TOPSIS analysis.	Optimising policies and regulations for zero routine gas flaring and net zero - currently under review in *Clean Technologies and Environmental Policy Journal.*

emissions by 2050 whilst addressing good governance, justice, and fair implementation.	(ii) How can these criteria, sub-criteria, and alternative policy scenarios be prioritised, selected, and benchmarked to stimulate flaring reduction actions? (iii) What are the optimal gas flaring policies/regulatory framework criteria and sub-criteria, presenting the best alternative policy scenario to stimulate flaring reduction actions?		regulations and effective approach to stimulate the elimination of routine gas flaring by 2030 and achieve net zero emissions by 2050 whilst addressing issues of good governance, justice, and fair implementation.		

Source: Author.

1.8.3. Epistemological Considerations

As argued by Fazey et al. (2018) and Hammersley and Atkinson (2019), one cannot eliminate the influence of the researcher when undertaking primary data collection and research. However, this influence needs to be understood and used productively to answer the research questions. This subsection outlines my philosophical assumptions and how they influenced the methodological considerations for collecting and analysing data. Before pursuing my PhD, my academic background focused on applied geophysics and environmental science. These fields typically take a top-down research approach, prioritise external validity (Campbell & Stanley, 2015; Chen, 2010) and are typically grounded in a positivist research philosophy, which assumes that objective truth can be observed. This approach prioritises quantitative data collection, large sample sizes, and a deductive, deterministic research methodology.

In comparison, social sciences, mainly qualitative social sciences, tend to follow a research philosophy that leans towards constructivism-interpretivism (Creswell, 2013). This philosophy acknowledges that multiple ways of understanding the world from different individuals' subjective beliefs and experiences give rise to various truths (ibid.). Its main goal is to comprehend the intricate world of lived experience from the standpoint of those who experience it (Schwandt, 1998), prioritising a bottom-up perspective and validity (Yue, 2012). This approach reflects the differences in ontological and epistemological views between natural and social science disciplines (Creswell, 2013). These varying perspectives reflect the contrasting views on the nature of reality and the relationship between the researcher and the research subject.

Throughout my PhD, I sought to expand my knowledge by exploring diverse disciplinary perspectives on public policy and social science theories. By studying taught units in public policy and research methods, particularly qualitative and mixed methods, in preparation for commencing research in a new discipline, I developed a reflexive and deeper understanding of how my beliefs and experiences could influence my research process and findings. As my research progressed, my philosophy shifted towards pragmatism, which aims to balance objectivity and subjectivity. Therefore, this thesis adopted a pragmatic approach, embracing a plurality of methods and using mixed methods to answer the research questions.

In exploring the knowledge gaps in gas flaring policies and regulatory framework, weak governance structures, and justice challenges, this research incorporated objective and subjective truth within its conceptual framework. In this approach, truth is determined by what works within a specific context and is relative to different actors' perceptions (McCaslin, 2012). A pragmatic approach prioritises research outcomes over any single method or philosophy and allows for multiple methods and mixed assumptions in data collection and analysis to answer research questions effectively (Creswell, 2014). Furthermore, the pragmatist worldview recognises that there is no best method or philosophy to approach research and encourages diverse paradigms and assumptions. As this study aims to answer "what" and "how" questions, a pragmatic approach was well-suited. Thus, this study prioritises research outcomes over any single method or philosophy and uses philosophical and methodological approaches that can effectively answer the research questions. Since this view is frequently linked with mixed methods (Creswell & Plano Clark, 2011; Johnson & Onwuegbuzie, 2004; Morgan, 2014; Teddlie & Tashakkori, 2009), a pragmatic and mixed methods approach was adopted to answer the research questions set out in section 1.3.

1.9. Methodology and Methods

The thesis uses mixed methods research, combining qualitative and quantitative data collection and analysis to achieve its objectives. Qualitative research provides a deeper understanding of societal realities through non-numerical data, such as beliefs and attitudes (Leedy & Ormrod, 2015), to address issues of societal concern, while quantitative research seeks a breadth of knowledge and is able to quantify (Patton, 2002). This study uses a literature review, in-depth semi-structured interviews, expert perception surveys, Q-method survey and exit interview, document review and knowledge/expert surveys (see Aigbe, Cotton and Stringer, 2023; Aigbe, Stringer and Cotton, 2023). Purposeful snowball sampling was used to recruit participants for interviews and surveys. Chapter 2, objective 1 employed a literature review, and chapter 3, objective 2 utilised in-depth semi-structured interviews and expert perception surveys. Chapter 4, objective 3 used the Q-method survey and exit interview, while chapter 5, objective 4 employed literature and document review, interviews, expert surveys, Analytical Hierarchy Process, and G-TOPSIS methodology.

In chapter 2, a literature review was conducted to construct the theoretical grounding from which this thesis was developed. A literature review is a research method that thoroughly searches for and analyses existing literature on a particular topic or research question, delivering a comprehensive and replicable summary of the current knowledge (Petticrew &

Roberts, 2008). It was useful in assessing the current state of development in global gas flaring processes and management.

The literature review developed in chapter 2 and the three analytical chapters (3, 4 and 5), along with the data collected during the interviews and expert surveys, facilitated the identification of the gaps and issues around gas flaring across scales. The review conducted during this research comprised documents in the English language only and included peer-reviewed academic literature and policy briefings, public policies, national development plans and reports from national institutions, and agreements and reports from international organisations, such as UNFCCC (NDCs) and the World Bank. There were no restrictions on the publication year.

Chapter 3 employed Qualitative Document Analysis (QDA) to undertake a horizontal-level policy coherence analysis of gas flaring at the local/national level to identify the principal key actors involved in such policies, what informs the implementation of policies in a complex governance structure, as well as understand the possible environmental and societal implications of the approval of those policies. Documents are key sources of information since they are stable, exact and have extensive coverage (Yin, 2009), though they could be biased as they are often written for a specific purpose. They must be corroborated with other sources. Accordingly, I used documentary sources as one of the key data collection instruments in Qualitative Document Analysis (QDA), alongside a MLG and policy review to develop core themes and subsequent interview and expert survey questions. The documents used as data collection instruments included the National Energy Policy 2003, National Policy on Climate Change 2013, Intended Nationally Determined Contribution (INDC) 2015, National Gas Policy 2017, National Action Plan to Reduce Short-Lived Climate Pollutants 2018, Nigeria-Economic Sustainability Plan 2020. These sources were accessed online and downloaded from government department websites. The QDA analysis of these policy documents was instrumental in identifying themes and points of inquiry, forming the basis for constructing interview and survey questions.

Qualitative content analysis was used to analyse these documents since it allowed the examination of language to classify large amounts of text (Weber, 1990). This approach was imperative since qualitative content analysis "provides knowledge and understanding of the phenomenon under study" (Downe-Wamboldt, 1992; p. 314). Also, qualitative content analysis as a research method is suitable for the subjective interpretation of the content of text data through a systematic classification process of coding and themes (Hsieh and Shannon, 2005). However, one of its limitations is limited data (Weber, 1990).

Interviews were also undertaken. However, a major challenge was engaging with government officials in Nigeria due in part to the tight control exercised by the federal government over the various ministries. Attempts were made to schedule interviews with the five federal institutions responsible for gas flaring management in Nigeria. Still, tight control from high-level managers meant that participation was declined in every instance. Furthermore, 30 employees of these federal ministries, institutions, and agencies who were contacted refused to participate in the study due to "instruction from the top" requiring them not to participate in the project to protect the government's interest. However, seven experts (4 representatives from Environmental NGOs and advocacy groups and 3 activists) were interviewed to enable validation, while 23 industry experts and ordinary citizen stakeholders participated in the expert/perception survey.

Chapter 4 utilised the Q-method, a mixed-method research approach that combines factor analysis with qualitative interpretation to elicit factors that correlate to scores assigned to pre-defined statements, providing insight into respondents' subjective attitudinal perspectives and conventional viewpoints around global gas flaring and energy justice issues. Given the complexity of the variables involved in gas flaring issues, such as the role of host communities, governments, and IOCs in gas flaring processes, it was essential to use such a research design to understand the relationships between these variables and to compensate for the mutual and overlapping weaknesses of each system, as every method has specific strengths and limitations (Kelle, 2006). Specifically, the Q-methodology approach added explanatory value to the qualitative depth (see Aigbe et al., 2023).

Chapter 5 employed the Analytical Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (G-TOPSIS) methodology to examine global gas flaring policies and regulatory frameworks and develop alternative policy options. These options considered existing frameworks and actions to stimulate actions in meeting key targets (the 2030 zero routine flaring (ZRF) and broader net zero emissions (NZE) by 2050 target) while seeking to reduce injustice in implementation processes. AHP, introduced by Saaty in the 1970s, is among the most adopted multi-criteria decision analysis (MCDA) techniques to illustrate complicated decision-making problems. It is a simple principle of arbitrary calculation and a standard tool for assigning weights to compare other parameters/alternatives. The AHP presents a robust model for decision-making, rating, and prioritising issues, enabling management and formulation of a hierarchical model. Furthermore, the Technique for Order of Preference by Similarity to Ideal Solution (Grey TOPSIS), developed in 1981 by Yoon and Hwang, was used to determine and select the optimal positive and negative solutions within several alternative gas flaring policies and regulatory frameworks (Yoon & Hwang, 2007). Combining AHP and G-TOPSIS in this chapter was important because it allowed for a more extensive and accurate analysis of complex decision-making processes by comprehensively analysing the various criteria and sub-criteria involved. While AHP provided a framework for prioritising and weighting criteria, G-TOPSIS helped to evaluate the performance of alternatives based on those criteria. Together, they offer a powerful tool to make informed choices and optimise outcomes.

Several tools, methods, and theoretical underpinnings were considered for each research question and each chapter's specific objective, as they involved themes as diverse as MLG and policy coherence, energy justice and regulatory framework aspects of gas flaring. All the empirical chapters draw on a literature review to substantiate the evidence from other sources (such as documents, interviews, and expert surveys). Using different methods for the various analytical chapters allowed the identification of aspects that would not have been captured if only a single approach had been used (Table 1.1). Key criteria and sub-criteria were identified to explore and develop alternative scenarios for gas flaring policies and regulatory frameworks through various methods. These included interviews and expert surveys conducted in Nigeria and 15 other top gas flaring countries globally. These results aim to stimulate actions towards meeting the goals of Zero Routine Flaring by 2030 and Net Zero Emissions by 2050 while ensuring fairness in implementation.

To assess the interstitial multi-scalar dimensions of gas flaring issues, the primary data source was 41 semi-structured and exit interviews and 41 expert surveys with 87 expert participants from 16 top gas flaring countries worldwide. This included 7 in-depth semi-structured interviews with representatives from environmental NGOs and advocacy groups, environmental campaigners, and ordinary citizen stakeholders, 34 exit interviews, 35 Q surveys and 46 participants in the expert survey, selected to represent a diverse mix of institutions and countries of expertise (Tables 1.2, 1.3 and 1.4). The study was conducted between December 2020 and February 2023 in three steps, as presented in the three analytical chapters 3, 4 and 5.

The choice of experts in both the semi-structured interviews and expert surveys follows the complexity of global gas flaring issues. Interview respondents were asked several questions concerning gas flaring governance, policies, processes, and management, but experts were free to discuss gas flaring issues in general. Those interviewed were purposefully selected to represent the diverse array of stakeholders involved directly or indirectly with gas flaring, from citizen-stakeholders from gas flaring host communities, academics and people with higher education and training in environment and related fields, non-affiliated citizen stakeholders living in gas flaring host communities, regulatory and technical advisors, legal and environmental consultants, and ordinary citizens (Tables 1.2, 1.3 and 1.4). These tables offer an overview of respondents by country, gender, focus area, and sector. In all cases, participants were guaranteed anonymity and not prompted for responses, and to encourage honesty and openness and protect respondents, such data were presented as anonymous.

After the basic literature framework was developed, face-to-face interviews (replaced with Zoom video interviews due to COVID-19 restrictions) were planned for objective 2 (Chapter 3). The Zoom video interviews assessed the level of knowledge regarding gas flaring issues in Nigeria and identified the gap between the local, national, and international gas flaring scenario and context.

Table 1.2. Overview of research interviews and expert survey respondents (Nigeria case study).

Nigeria case study (State)	Interviews (*n=7*)	Respondents (*n=23*)
Abia		2
Akwa Ibom	1	2
Bayelsa	1	3
Cross Rivers	2	
Delta	1	3
Edo	1	3
Imo	1	2
Lagos		1
Ondo	1	2
Rivers	1	3
Gender		
Male	6	20
Female	1	3
Sector		
NGO representative	4	2
Environmental Campaigners/Citizen Stakeholders	3	1
Oil & Gas industry		5
Academics/Citizen stakeholders		4
Law & Governance (Public Policy Legal Consultant)		3
Energy & Environmental Management		2
Consultancy		1
Project/Engineering Management		2
Ordinary Citizen stakeholder		3

Source: Author.

Table 1.3. Overview of research Q-method exit interviews and survey respondents.

Country	Exit Interviews (*n=34)*	Respondents (*n=35*)
Angola/France/UK/Nigeria	3	3
Canada	3	3
Côte d'Ivoire	1	1
Egypt	1	1
France	3	3
Germany	1	1
Iran/ UK	1	1
Mexico	1	1
Netherlands	2	2
Nigeria	8	9
Norway	1	1
Qatar/UK/Nigeria	1	1
UK	3	3
USA	5	5
Gender		
Male	29	29
Female	5	6
Sector		
Academics/Industry experts	4	4
Industry Stakeholders/ Scientific	2	2
Oil & Gas industry	9	9
Directors, law & regulatory, governmental, and NGO stakeholders	12	12
Energy Consultancy	1	2
Ordinary Citizen stakeholder	3	3
Others	3	3

Source: Author.

Table 1.4. Overview of research Expert survey respondents.

Country	Respondents (*n=17*)
Angola/France/UK/Nigeria	3
Canada	1
Egypt	1
France	3
Germany	1
Iran	1
Mexico	1
Netherlands	1
Nigeria	9
Norway	1
Qatar	1
UAE/Oman/Nigeria	1
UK	3
USA	5
Gender	
Male	15
Female	2
Sector	
Academics/Industry experts	4
Industry Stakeholders/ Scientific	2
Oil & Gas industry	9
Directors, law & regulatory, governmental, and NGO stakeholders	12
Energy Consultancy	1
Ordinary Citizen stakeholder	3
Others	3

Source: Author.

1.9.1. Positionality and Reflexivity

I approached the research from an ‘outsider/observer to an insider/fellow’ Nigerian position. I was born and raised in Niger Delta, Nigeria; hence, I am familiar with the context of the rural Niger Delta host communities. This allowed me to research and contact principal stakeholders in Nigeria, though tight political controls over gas flaring information still resulted in participants' declining invitations. Additionally, due to COVID-19 travel restrictions, I could not be physically present in Nigeria, and face-to-face interviews were replaced with Zoom video interviews. This also contributed to and resulted in several participants dropping out of the research. However, being born in Nigeria gave me some advantages during the Zoom video interviews and expert surveys. This made communicating with people in the local host communities in everyday situations easier, creating a more fluid concept of power. According to Torres (1992), theory should incorporate a flexible understanding of power as a dialogue-based relationship. This facilitated meaningful engagement with the participants while being ethically sensitive to the various cultures during interviews (data collection) (Twyman, Morrison and Sporton, 1999; Given, 2012). As someone who grew up in one of the local host communities and can communicate fluently in various Nigerian languages, including the popular Pidgin English, such dialogue can never be restricted to the dominant face of power.

Conducting field research in a familiar context to the researcher has an inherent challenge of positionality (Moore, 2012), while ontological and epistemological beliefs of the researcher influence their research (Darwin Holmes, 2020). While researching from an insider perspective has advantages, there is a risk of unintentionally seeking information that confirms one's pre-existing beliefs or opinions on the topic being studied or where preconceived notions or beliefs about the topic may influence the interpretation of data and lead to confirmation bias. To reduce this, I consciously and critically evaluated and documented my experiences and thoughts on gas flaring in Nigeria and globally. This allowed me to determine my position within the discourse, maintain objectivity, and avoid undue influence on the research process.

1.9.2. Language and Translation

All the interviews were conducted in English, the researcher’s second and official language. Although the representation of participants’ experiences remains bound by the researcher’s interpretation and level of subjectivity (Van Nes et al., 2010), insights and meanings were not lost during transcription. In all the interviews, I did not correct respondents or normalise or modify their answers. This implies that, at times, respondents were speaking to their perceptions rather than absolute or definitive facts. Therefore, all quotations used in this thesis were not modified but conveyed the narratives’ true meaning.

1.9.3. Ethical Considerations

The University of York, Department of Environment and Geography Committee on the Ethics of Research on Human Beings approved all the fieldwork (See Chapter 1 Appendices 1A, 1B and 1C for the Environment Department, University of York Research Ethics Approval Forms). An information sheet was presented to participants in the three fieldwork chapters (Chapters 3, 4 and 5) to ensure ethical standards were upheld. The sheet outlined the study's purpose, the participants' involvement, potential risks and activities, the importance of free and informed consent, the option for voluntary participation and withdrawal from the study, anonymity and confidentiality, and data access and protection. All participants were required to provide written or verbal informed consent before data collection began. As the research consisted of three stages, forming the three analytical chapters, at the beginning of the study, participants were informed that their permission might be required for each stage of the research project.

Following the university’s ethical guidelines, the anonymity of the various participants was kept private and protected throughout. Despite the guarantee of anonymity, some participants working under various federal institutions responsible for gas flaring management in Nigeria and some IOCs were concerned about potential threats against them from the government and IOCs. Participants’ identities were kept anonymous to ensure confidentiality, and respondents’ names were changed. All respondents were grouped into different categories and numbered, e.g., Environmental Campaigner 1, NGO Representative 3, etc. Scholars interviewed in this study are referred to as academics or people with higher education; NGOs’ names were changed to NGO representatives.

Data from qualitative and quantitative studies have ethical issues to be considered individually. Combining qualitative and quantitative analyses created issues, particularly in data collection, processing, and storage. Due to the extensive literature on gas flaring, there was a tendency to prioritise literature over the needs of the participants. To mitigate this limitation, first, I kept the research question and participants' needs in mind. This meant being open to new ideas and perspectives, revising my assumptions and hypotheses as further information came to light, being aware of any personal biases or assumptions I may have, and taking steps to address them. I also tried to understand the participants and their perspectives through the interviews and surveys, seeking participant feedback throughout the research process and reading relevant literature. Finally, it was crucial that I focus on the research goal, which aims to benefit society as a whole and not just to advance the interests of the researcher or the field of literature.

Recognising that researchers are not completely independent in their work is essential. Prior experiences, understanding, scientific paradigms, and societal influences such as culture, politics, and funding all influence how research is conducted, interpreted, and used (Fazey et al., 2018). Accordingly, researchers are embedded within the systems they observe, making them inseparable from their work (ibid.). During my interviews, some members of the local host communities who were also participants expressed a desire for my research to help protect their lands and environment. While I sympathised with their plight, I explained that I did not have the authority to address their immediate challenges caused by flaring. However, I did acknowledge that my research could increase awareness of what was happening in the region. Although I understand the extent of gas flaring's impacts on their livelihoods (mainly farming), I emphasised that I could not change the injustices and alleviate the adverse effects of flaring, reaffirming that researchers are also perhaps always interveners (Fazey et al., 2018). Research needs to consider action, learning, and the generation of new knowledge as more closely interconnected. It is also essential to approach research as a reflective practice emphasising solution processes.

1.10. Conclusion

In this chapter, the thesis methodology and framework for investigating the research questions have been detailed. The most appropriate approach for producing rich, context-specific data was determined to be the case study approach. Additionally, it has been established that conducting mixed-methods research combining document analysis, semi-structured interviews, exit interviews, and expert surveys is necessary to gain original insights into gas flaring issues at local, national, and global scales.

Chapter 2 advances to address objective 1 and explores the systems approach to global gas flaring issues using a literature review. This sets the foundation for the rest of the thesis by enhancing theories of global gas flaring by proposing a new perspective that includes multilevel governance and energy justice in a systems approach. It argues that a whole systems approach can improve the system by increasing awareness of human needs and actions, integrating multilevel governance, policy coherence, good governance, and energy justice.

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Chapter 2

Whole systems approach to global gas flaring: Integrating multilevel governance, policy coherence, good governance, and energy justice.

Abstract

Global gas flaring involves complex governance and has justice implications, requiring a holistic approach. However, the current understanding of natural gas resources and its subsequent global gas flaring issues remain fragmented. Although the effects of gas flaring on the environment and economy have been analysed independently, the full extent and diversity of its implications, from resource extraction to waste disposal and governance, have been overlooked, and many debates fail to consider gas flaring holistically from a systems perspective. This chapter aims to reconceptualise and enhance theories linked to global gas flaring by proposing a new perspective on global gas flaring issues. Considering these circumstances, it argues for a new approach to addressing global gas flaring issues that includes a systems approach by analysing and connecting literature on multilevel governance (MLG), policy coherence, good governance, and energy justice in a single framework. Using the inductive interactionist approach, this chapter seeks to understand better the connections and feedback between the different parts of the system and use these insights to inform improvements to the system. Analysing the literature highlights the limitations of a singular approach to addressing global gas flaring issues. It argues that a whole systems approach can improve the system by increasing awareness of human needs and actions, integrating MLG, policy coherence, good governance, and energy justice. The chapter delivers crucial insights into how gas flaring can be perceived, approached, and addressed at different levels. It also demonstrates that an integrated approach to global gas flaring analysis offers the potential for better understanding across scales and levels. Therefore, this perspective contributes significantly to the theoretical concepts of MLG, policy coherence, good governance, and energy justice.

Keywords: Governance, implementation, inductive interactionist approach, energy justice, case study

2.1. Introduction

The natural gas resource system, a microcosm of the entire energy system, is a crucial public good that benefits millions globally. However, the practice of gas flaring within the energy system raises important theoretical questions about policy and governance concerns (Agbonifo, 2016; Babalola & Olawuyi, 2022; Bello, 2023; Buzcu-Guven & Harriss, 2014; Mrabure & Ohimor, 2020; Svensson, 2005), local and global justice including the benefits and burden of natural gas and flaring (Babalola & Olawuyi, 2022; Cushing et al., 2021; Franklin et al., 2019; Iguh, 2016; Johnston et al., 2019, 2020; Okeagu et al., 2006), global externalities caused by greenhouse gas emissions, pollution, and health impacts and how these factors impact the human rights and values of the people affected (Aigbe et al., 2023; Fox & Ward, 2008). These energy issues that come with energy, due to its significant social, economic, and environmental impacts, including ineffective governance, need to be acknowledged when making decisions (Stagl, 2006). However, the current understanding and framework of natural gas resources and its subsequent global gas flaring issues are fragmented, requiring a holistic approach, from natural gas resource extraction to waste disposal (Gagnon et al., 2002; Jenkins et al., 2014; Martiskainen et al., 2021). This also includes global flaring policies and governance. By analysing and connecting literature on MLG, policy coherence, good governance, and energy justice in a whole system framework, this chapter illustrates the utility of systems thinking and argues for a new approach to addressing global gas flaring. In doing so, it integrates MLG, policy coherence, good governance, energy justice, and whole-systems literature, thus providing a new way of thinking about global gas flaring. Figure 2.1 shows the various elements in the lifecycle of natural gas to gas flaring system that are interrelated, interdependent, or interacting with each other within the natural gas and global gas flaring system. These elements are all interconnected in multiple ways and rely on one another to abate global gas flaring.

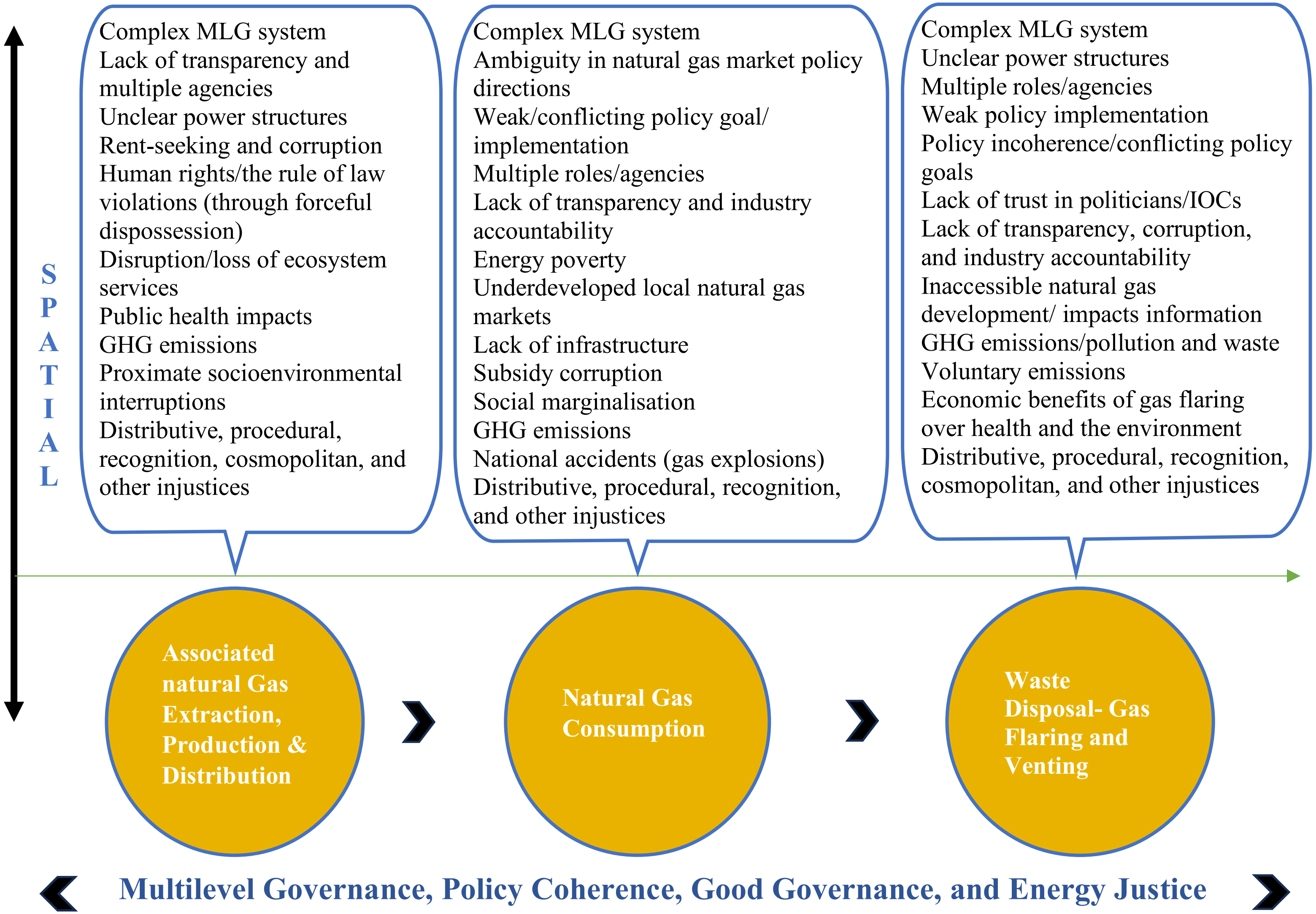

Figure 2.1. Conceptualising the systems thinking approach to global gas flaring, as applied in this thesis.

Gas flaring, the wasteful burning rather than utilising or preserving associated gas, is a by-product of oil production (GGFR/The World Bank, 2023) and involves the energy system. By including the political, social, and cultural dimensions of gas flaring activities, the approach taken in this thesis enables a considerably more nuanced understanding of the dynamics of systems change, advocating more aggressive global gas flaring reductions than the conventional conservative system, which takes a more moral environmental framing to addressing flaring reduction (e.g., Lakoff, 2010). It also responds to calls for new and integrated perspectives and research to comprehend the complex connection between the global transformation of social and natural systems (Biermann, 2012; Biermann & Gupta, 2011; Dryzek & Stevenson, 2011), and good governance (Lavrijssen & Vitéz, 2021; Ramirez & Ramirez, 2021; Sovacool & Dworkin, 2015).   Within the scope of MLG, policy coherence, good governance and energy justice research, the issue of global gas flaring has been frequently overlooked. By analysing current theoretical debates and examining how policy coherence impacts policy implementation in complex governance structures across various levels and stages of the gas flaring system, a systems approach can integrate critical concepts such as MLG, policy coherence, good governance, and energy justice, allowing for a more holistic approach to policymaking and decision-making. The effectiveness of this approach is demonstrated through a brief examination of MLG, policy coherence, good governance, and energy justice in the following sections. Table 2.1 summarises the lifecycle stages of natural gas to gas flaring issues and injustices.

Table 2.1. Summary of lifecycle stages of natural gas to gas flaring issues and injustices

Natural gas extraction and production	Natural gas consumption	Associated natural gas flaring
1. Complex multi-level governance system	1. Multiple roles/agencies	1. Complex multi-level governance system
2. Multiple roles/agencies	2. Complex multi-level governance system	2. Unclear power structures
3. Unclear power structures between the governments and IOCs	3. Ambiguity in natural gas market policy directions	3. Multiple roles/agencies
4. Policy incoherence	4. Weak policy implementation	4. Inadequate investment in regulating and enforcing gas flaring
5. Undermining the protection of human rights through dispossession and displacement of local host community by physical force, coercion, and intimidation (rule of law)	5. Lack of transparency and industry accountability	5. Weak gas flaring policy implementation
6. Community health	6. Lack of infrastructure in rural host communities	6. Conflicting policy goals between gas flaring policies and national measures or other sectors
7. Lack of infrastructure in rural host communities	7. Energy poverty (lack of energy access)	7. Policy incoherence between gas flaring policies and other policies
8. Rent-seeking and corruption	8. Underdeveloped local markets for natural gas	8. Political impacts of gas flaring
9. Lack of transparency and corruption	9. Lack of infrastructure to transport natural gas for local consumption	9. Lack of trust in politicians/IOCs
10. Diversion of taxes through government subsidies and incentives	10. Social marginalisation (lack of participation by all people)	10. Lack of transparency, corruption, and industry accountability
11. Political impacts of natural gas extraction (lack of trust in politicians/IOCs)	11. Safety, reliability, and national accident (gas explosions)	11. Inaccessible natural gas development information impacts
12. The slow violence of landscape (destruction, water contamination and livelihood disruption) farmland and drinking water)		12. Lack of voluntary disclosure of gas flaring emissions
13. Impacts wildlife and water resources (contaminates water)		13. Non-availability of data on gas flaring emissions, health impacts, and distribution patterns
14. Reduce property values in extraction proximity		14. Non-recognition of host communities' concerns about natural gas extraction and gas flaring impacts and development decisions
		15. Non-involvement of state and local government agencies
		16. Impacts clean water and green space for local host communities
		17. Interference with other neighbouring countries transitions
		18. Environmental impacts of natural gas extraction and gas flaring
		19. Hazardous waste streams (volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs))
		20. Transboundary socio-environmental injustices, conflicts, and pollution
		21. Sacrifice zone (environmental injustice)

15. Disturb local communities 16. Natural gas production produces air pollution and waste 17. Loss of jobs (IOCs export labour in the form of expatriates to the enclave regions) 18. Traffic congestion 19. Economic benefits over health and the environment	12. High household energy prices and Economic benefits 13. Lack of incentive and natural gas subsidies for local host communities	22. Unequal distribution of costs and benefits of natural gas and flaring 23. Ineffective Environmental Impact Assessment (EIA) 24. Lack of empowerment for the National regulatory agencies 25. Health complications (birth defects and certain cancers) 26. Reduce property values in flaring proximity 27. Impact on livelihoods and daily quality of life 28. Local pollution and waste 29. Economic benefits of gas flaring over health and the environment 30. Impacts of voluntary emissions and gas flaring reduction agreement

Source: Author.

2.2. Multilevel Governance (MLG)

Over the past four decades, governance has changed globally from federalism and power-sharing among states to political decentralisation within states. In contemporary studies and governance theories, new concepts, including multilevel, multi-tiered, polycentric, multi-perspective, and fragmented governance, have dominated the discourse, giving rise to new forms of environmental governance (Eckerberg & Joas, 2004). Literature shows that there has been a change from governments being solely focused on the state to a more diverse governance system. This involves supranational, national, regional, and local governments in policy networks spanning territories (Marks, 1993), cited in Stephenson, 2013, p. 820). It involves collaboration between various actors from the public, private, subnational, and supranational spheres working at different levels (Bulkeley et al., 2013; Bulkeley & Betsill, 2005; Hooghe & Marks, 2003; Stephenson, 2013; Westerink et al., 2017). MLG, thus, is a system of continuous negotiation at various territorial tiers involving vertical and horizontal coordination between governments, non-government actors, and civil society (Marks, 1993).

The change within MLG is grounded in the belief that involving a wide range of citizens and interest groups will enhance the validity and effectiveness of the resulting policies (Rauschmayer et al., 2009; Stephenson, 2013). Thus, it is reasonable to assume that in processes of MLG, the various host communities and those who utilise resources would have a higher degree of influence in determining the regulations that govern those areas, as such a system improves local initiatives through the sustainability of networks for the diffusion of best practices and enhanced collaboration across levels (Underdal, 2010). While research has indicated that MLG can empower individuals and improve decision-making by tackling social issues on the appropriate scale, it has also shown that a polycentric governance system involving multiple agencies and governance levels produces better environmental outcomes than a monocentric system (Newig & Fritsch, 2009). For example, Westerink et al. (2017) highlight the importance of involving farmers in the governance and design of agri-environmental schemes to address environmental issues at a landscape level effectively. This observation is supported by the findings of Beckmann et al. (2009). Other studies have pointed out concerns regarding accountability and democratic issues in MLG. This is due to power distribution among different levels and actors, which may lead to fragmentation and conflicts (Arts, 2014; Harlow & Rawlings, 2007; Kim & Schmitter, 2005; Knox-Hayes & Hayes, 2016; Stephenson, 2013).

Global environmental issues such as gas flaring with negative impacts on humans and the environment are MLG complexities. Hence, gas flaring nations also need to think beyond the formal institutions, including the state, constitutional mandates, and fiscal federalism (Fawcett & Marsh, 2020). For this thesis, MLG within the gas flaring context refers to the distribution of power, authority, and decision-making processes across different local, regional, national, and international levels (Bulkeley & Betsill, 2005; Bulkeley & Castán Broto, 2013; Hooghe & Marks, 2003). The MLG approach describes a diverse and distributed governance process and recognises that different levels of governance have different roles to play in achieving gas flaring policy objectives. This requires a coordinated effort to achieve the 2030 zero routine flaring target. At the global level, the United Nations has set the 2030 zero routine flaring target and guides how to achieve it, while the World Bank provides financial and technical assistance to countries to facilitate the reduction of gas flaring. At the regional and national levels, governments are responsible for implementing policies and regulations that reduce gas flaring, while local governments are responsible for monitoring and enforcing regulations.

MLG, characterised by collaboration among governments and non-governmental actors, has been used to examine the policymaking process in the literature on environmental governance and natural resource management (Fawcett & Marsh, 2020). It has also been used in analysing the complexity of decision-making in solving environmental problems (Bulkeley et al., 2003; Hooghe & Marks, 2003; Newig & Fritsch, 2009). In Europe, there has been a significant rise in MLG and participatory methods in policymaking since the 1990s (Benoit & Patsias, 2017; Newig & Fritsch, 2009; Newig & Koontz, 2014). It has been applied in environmental governance and transnational municipal networks in Europe (TMNs) (Bulkeley et al., 2003). However, it has not been used in advancing the understanding of gas flaring issues. To holistically address the complexities of long-term environmental challenges, such as gas flaring, it is imperative to shift focus towards a decentralised system involving local, national, and global MLG structures (Newig & Fritsch, 2009). As global gas flaring also falls within the MLG structure challenged by governance, decision-making process and policy implementation, objective 2, chapter 3 of this research focuses on governance structures to examine Nigerian gas flaring policy implementation challenges. At the national level (the Nigeria gas flaring context), MLG is conceptualised to analyse the complex governance structure and (in) coherence of policies in gas flaring management.

2.3. Policy Coherence

In a complex MLG system, achieving policy coherence can be challenging due to conflicting goals and rules (Sandström et al., 2019), especially in the global south, where other policies and regimes can impact environmental governance instruments, leading to conflicts with sustainable development measures. Specifically, in the context of MLG, the efficiency of environmental governance tools can be influenced by other regimes/policy instruments. Concerning global gas flaring, effective governance structures and public participation are crucial. Therefore, it is important to consider cross-scale interactions and the interplay between policy goals and regimes across different levels of governance within the gas flaring system, a concept introduced by Young (2002).

Policy coherence is increasingly crucial in governance and policymaking within the EU, as highlighted by Nilsson et al. (2012). It considers the degree to which policy conflicts are managed or the extent to which they occur concerning multiple societal goals during the implementation process (Söderberg, 2016). Friberg-Fernros (2008, cited in Söderberg, 2016) suggests that coherence is the alignment between normative and empirical beliefs, ensuring consistency and avoiding contradictions. According to Nilsson et al. (2012), policy coherence refers to policies that minimise conflicts and enhance cooperation among policy areas to achieve common goals. Similarly, May et al. (2006) describes policy coherence as coordinating policies that share similar ideas or objectives. When examining coherence, May et al. prioritise issue concentration, interest concentration, and policy targeting. In this thesis, policy coherence refers to the consistency and harmony between various policies and strategies, ensuring that different policies do not contradict or undermine each other and work towards achieving the same goal. It also refers to the level of convergence and divergence between different sectors.

Across various domains, policy layers interact in two different ways. The first type is horizontal and vertical, which distinguishes policies on the same level of governance from those at different levels. More specifically, horizontal coherence involves comparing and studying the goals and objectives of different policy initiatives and ensuring institutional consistency. The second type is internal and external, which separates interactions within a single policy from those across policies and policy spheres (Den Hertog & Stroß, 2013; Deters, 2018; Nilsson et al., 2012). It is essential to acknowledge that varying procedures and interests will influence policies developed in different parts of institutional machinery (Olsen, 2008). Though institutional inconsistencies may arise from different approaches to the same problem and actors pursuing different objectives (Olsen, 2008), successful regimes establish behavioural mechanisms that guide key actors, and these regimes incorporate steering systems to monitor progress towards desired outcomes and adapt regulatory measures to achieve objectives. Accordingly, coherence is necessary to achieve zero routine flaring in gas flaring reduction policies without compromising other environmental policy goals.

Nilsson et al.'s (2012) study that considers policy outputs and implementation practices argues that policy coherence can be achieved by balancing different societal goals. Also, they suggest that by learning from policy coherence analyses, conflicts can be reduced while synergies between policy areas can be harnessed to achieve mutually agreed policy objectives. Huttunen et al. (2014) and Mickwitz et al. (2009) suggest that policy goals, instruments, and outcomes must be consistent, aligned, and interconnected for policy coherence. This approach emphasises the importance of successful regimes and the avoidance of policy conflicts. Previous studies (e.g., May et al., 2006; Nilsson et al., 2012; Olsen, 2008; Young, 2002) suggest that the EU and national governments could reduce policy conflicts by carefully considering different objectives when creating new policies. While policy coherence has been crucial in governance and policymaking (Nilsson et al., 2012), measuring policy coherence is complex (May et al., 2005, 2006).

Various governance arrangements can shape power structures and implementation practices nationally and globally, influencing how policy incoherence affects implementation. Hence, different governing systems can lead to varying outcomes in policy implementation. Also, as most gas flaring nations implement different gas flaring policies while few countries shift towards different MLG structures, examining policy coherence across levels is crucial. Understanding how policy coherence impacts policy implementation in complex governance structures across levels is essential. To achieve the 2030 zero routine flaring target, policies aimed at reducing gas flaring must consider the negative impact of flaring on host communities and align with national goals. Most gas flaring nations in the Global South have heavily centralised governance structures that prioritise personal rule over public involvement, collective objectives, and societal needs, leading to conflicting policy goals. Considering this, Nigeria was selected as a leading case study covering local and national scales. Chapter 3 of this research (Objective 2) explores Nigeria's gas flaring governance, decision-making process and policy implementation and their coherence with other policy goals within the established systems approach.

2.4. Good Governance

Good governance spans the different interactions in the natural gas and gas flaring system, connecting the MLG perspective and policy to energy justice. Though recent, the concept has gained significant attention in high-level policy discussions. While it is particularly relevant in developing countries and those undergoing a transition, the issue of poor governance is an issue in most gas flaring nations globally. Bad governance can rapidly deteriorate an entire country's economic state. However, despite the potential harm, in the Western world, a well-developed administrative system can mitigate the consequences of bad decisions. Additionally, citizens can hold their leaders accountable through the democratic process and future elections (Kłosowicz, 2018). Ensuring equitable growth in developing countries heavily relies on improving governance. According to the World Bank report, implementing effective policies can be challenging as influential groups benefitting from the current system may resist the necessary reforms to disrupt the political balance.

The good governance agenda focuses on whether a society possesses political, legal, and administrative institutions that enable effective policymaking and implementation for the greater public good. Studies have shown that good governance, which primarily focuses on the effectiveness of the political system, is strongly correlated with positive outcomes related to human well-being and has been observed to have a greater impact on human well-being than measures of democracy (Rothstein, 2012).

The principle of good governance advocates for providing all individuals with high-quality information on energy, specifically gas flaring and the environment. It suggests that information, transparency, and accountability are crucial to promoting good governance in various sectors to reduce corruption and improve accountability. It centres on democratic and transparent decision-making processes, financial accounting, measures to reduce corruption, and energy policies and revenues publication. Access to information and transparent frameworks that preserve such access have been known to encourage democracy, enhance social stability, and increase business confidence (Sovacool & Dworkin, 2015).

Good governance is crucial in global gas flaring management, like energy democracy (Rothstein, 2012; Sovacool & Dworkin, 2015; Van Veelen, 2018). It involves reducing corruption, upholding the rule of law, fostering trust in elected officials, increasing accountability, promoting transparent decision-making processes, sharing accurate information about energy and the environment, ensuring the participation of all members of society, and ultimately, advancing the common good. Good governance also aligns with Goal 16 of the Sustainable Development Goals, which focuses on "Peace, Justice, and Strong Institutions". However, in developing economies, the importance of strong institutions is often challenged (Doh et al., 2017; Luiz et al., 2019; McDermott et al., 2019).

Like renewable energy investments directly impacting communities, effective governance in gas flaring management is crucial in energy democracy (Velasco-Herrejon & Bauwens, 2020). Also, natural gas extraction and gas flaring are frequently located in impoverished, rural regions of emerging markets. These areas are also home to indigenous communities with a history of challenging corrupt governments and opposing International Oil Companies (IOCs). Implementing public policies involving and incorporating local communities to reduce conflicts while shifting towards a decarbonised economy is crucial. Additionally, collaborating with communities can benefit multinational oil companies as they may possess the knowledge or resources that the IOCs require (Doh et al., 2017; Madriz-Vargas et al., 2018). However, a lack of good governance in the gas flaring system may impede opportunities for community involvement (Sovacool & Dworkin, 2015; Szulecki, 2018). Understanding the role of good governance in energy democracy and global gas flaring and how public policies affect indigenous communities can aid in the shift towards a decarbonised energy sector (Ramirez & Ramirez, 2021).

This chapter posits that a major obstacle to achieving energy democracy and establishing partnerships with gas flaring local host communities is the issue of lack of good governance in most gas flaring emerging nations, particularly in the Global South. Although this chapter's argument for good governance is developed through a literature review, examining the changing balances of implicit and explicit good governance more broadly is important. The literature presents governance as a complex and multifaceted concept, with its definition and evolution influenced by the fields in which it is applied. While good governance involves and is rooted in ethical policy analysis, the state is the primary arbiter in extractive industries, including gas flaring (Ambe-Uva, 2017; Leonard, 2017; Pierre & Peters, 2020). Accordingly, this chapter focuses on ethical policy analysis of good governance and emphasises two distinct values. Firstly, performance values such as effectiveness and efficiency pertain to the output and outcome. Secondly, it emphasises that good governance goes beyond performance outcomes and includes energy justice, such as procedural values, that indicate the quality of the process (Graaf & Paanakker, 2014). These concepts are closely tied to global gas flaring management values, including MLG, policy coherence, and energy justice, as depicted in

Figure 2.1. They are also linked to fundamental governance principles, such as legitimacy, transparency, accountability, rule of law, responsiveness, and effectiveness. This conception enables citizens to hold the governments and public actors accountable for procedure and performance.

2.5. Energy Justice

To effectively tackle the problem of global gas flaring and its negative effects on the environment requires a comprehensive approach from policy implementation in complex governance structures and incorporating justice concerns in all parts of the natural gas and gas flaring system. Research has frequently focused on these issues separately or ignored parts of the energy system. While socio-natural injustices may vary from one level to another due to weaknesses in the country-specific policies and regulations, this chapter argues that the best way to address the criticisms of policies, governance, and justice concerns in global flaring is to take a systems approach to the global gas flaring system, encompassing MLG, policy coherence, good governance, and local and global energy justice. The various injustices that arise from natural gas extraction and global gas flaring are summarised in Table 2.2.

Table 2.2. Summary of scales of injustices from natural gas extraction to global gas flaring

Local injustices	National injustices	Global injustices	Across scales
1. Undermining the protection of human rights through dispossession and displacement of local host community by physical force, coercion, and intimidation (rule of law) 2. Community health 3. Lack of infrastructure in rural host communities 4. The slow violence of landscape destruction, water contamination and livelihood disruption) farmland and drinking water) 5. Lack of access to clean water and green space for local host communities 6. Various public health complications, such as the increased risk of birth defects and certain cancers 7. Reduce property values in extraction and flaring proximity 8. Impact on livelihoods and daily quality of life 9. Exclusion of rural host community areas 10. Local pollution and waste 11. Loss of jobs (IOCs export labour in the form of expatriates to the enclave regions) 12. Traffic congestion 13. Gas flaring within enclave economies alters the structure of host communities' job opportunities	1. Rent-seeking and corruption 2. Diversion of taxes through government subsidies and incentives 3. Lack of transparency and industry accountability 4. Lack of voluntary disclosure of gas flaring emissions 5. Non-recognition of host communities' concerns about natural gas extraction and gas flaring impacts and development decisions 6. Lack of host community involvement 7. Non-involvement of state and local government agencies 8. Energy poverty 9. Oil and gas enclave development 10. Unequal distribution of costs and benefits of gas flaring 11. Social marginalisation 12. Sacrifice zone 13. Non-availability of data on gas flaring emissions, health impacts, and distribution patterns 14. Inadequate investment in regulating and enforcing gas flaring control measures 15. Ineffective Environmental Impact Assessment (EIA) 16. Lack of empowerment for the National regulatory agency 17. Safety, reliability, and national accidents	1. Political impacts of natural gas flaring 2. Environmental impacts of natural gas extraction and gas flaring 3. Interference with other neighbouring countries transitions 4. Natural gas export 5. Hazardous waste streams, such as the release of volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and inorganic contaminants 6. Waste flows 7. Transboundary pollution 8. Transboundary socio-environmental injustices and conflicts	1. Lack of trust in politicians/IOCs (long-term community trust) 2. Lack of transparency and industry accountability 3. Undermining the protection of human rights through dispossession and displacement of populations 4. Lack of access to information about the impacts of natural gas development

The concept of energy justice can be traced back to the 1970s to address the unequal distribution of pollution and waste facilities in poor, minority communities. Its core principle was to ensure fair and equal treatment of all individuals in developing, implementing, and enforcing environmental laws and policies. The movement aims for social justice, empowerment, and public health (McCauley et al., 2013), though environmental justice has evolved beyond local community action to ensure a more equal distribution of harmful environmental effects.

Energy justice refers to the fair distribution of the benefits and burdens of energy production and consumption, including gas flaring. Energy justice ensures access to safe, affordable, and sustainable energy for all, regardless of location (McCauley et al., 2013). However, there is still a lack of awareness about the full extent of justice implications within the energy system. The impact of the entire energy cycle, from resource extraction to waste management, is often overlooked. Energy justice has been explored by scholars, such as Bickerstaff et al. (2009) and Sovacool, Hook, et al. (2019). Although energy justice has gained traction in recent years, several criticisms exist. While energy justice scholarship has long focused on three core tenets, other justice tenets, such as restorative, generational justice, retributive justice, economic justice, epistemic justice, and reparative justice, though crucial, are commonly excluded. For example, restorative justice in the energy sector aims to address the needs of those affected by harmful activities, including nations, citizens, and nature. More importantly, by restoring them to their original position before the harm, restorative justice can serve as a proactive policy approach to prevent conflicts and harm within the energy sector (Hazrati & Heffron, 2021).

Also, there is a need for a precise definition, a narrow focus on energy production and consumption, and a lack of attention to the political and institutional factors that shape energy decision-making. Despite the consensus that energy justice refers to fairness in distributing energy benefits and burdens, there is still much debate about what this means in practice (Sovacool, 2014). Some scholars argue that energy justice should be based on principles of distributive justice, while others suggest that it should be based on principles of procedural justice. Another critique of energy justice is its narrow focus on energy production and consumption. Energy justice tends to focus too heavily on issues related to access to energy, energy affordability, and the environmental impacts of energy production and consumption (Jenkins, McCauley et al., 2014) while neglecting gas flaring. While these are important issues, they do not address the broader social and economic inequalities that underlie energy injustice. A third criticism of energy justice is its lack of attention to the political and institutional factors that shape energy decision-making. Energy justice often assumes that energy decisions are made neutrally and objectively. Still, various political and institutional factors, such as the power of energy corporations and the influence of lobbyists, shape energy decision-making. Addressing these criticisms will be critical for advancing the cause of energy justice.

While energy justice recognises that energy production and consumption have social, economic, and environmental impacts that affect different communities and groups differently, its principles require that energy policies and practices are equitable, transparent, and participatory in underpinning this fair distribution. In the context of global gas flaring, energy justice requires that the benefits and burdens of reducing gas flaring, such as reduced pollution and improved health outcomes, are distributed relatively evenly across different communities, groups, nations and globally. It also requires that communities affected by gas flaring are involved in decision-making processes and consider their concerns.

Evaluations of socio-technical systems from a justice perspective have been extensively explored in applied philosophy, geography, and science and technology studies (Schlosberg, 2004, 2009, 2013), where cosmopolitan justice is commonly included alongside the other principles of distributive, procedural, and recognition justice. The justice framework used in this thesis is based on the four principles of justice theory, as outlined by Sovacool et al. (2017); Sovacool, Hook et al. (2019); Sovacool, Kester, et al. (2019), McCauley et al. (2019) and Heffron (2020): distributive, procedural, recognition, and cosmopolitan justice. Table 2.3 provides insight into the energy justice framework for global gas flaring, elaborating on an expanded environmental justice frame.

Table 2.3. A conceptualisation of the components of energy justice and how they can be applied to the issue of gas flaring.

	Gas flaring-specific concerns
Distributive Justice	The distribution of benefits and burdens in relation to natural gas exploration, extraction, and usage, as well as equity of access to green spaces, compensation to host communities, equal availability of energy (specifically, electricity), access to clean air and water, spatial patterns of gas flaring pollution risks, and the potential exposure to natural disasters and climate change impacts.
Procedural Justice	Natural gas and flaring planning processes, regulatory practices, environmental rights, due process, public participation, and decision-making mechanisms through deliberation.
Recognition Justice	Gas flaring affects vulnerable groups, especially minorities, people of colour, and indigenous people in gas flaring host communities. Lack of appropriate language in environmental communication, concerns for respect, self-governance mechanisms, and concerns about acknowledging community identity.
Cosmopolitan Justice	Global distribution of negative market externalities. For instance, releasing toxic pollutants, such as sulphur dioxide and NOx, can cause acid rain, smog formation, and low-level ozone. Additionally, GHG emissions, including CO_2, contribute to climate change.

Source: Adapted from several sources (Heffron, 2020; McCauley et al., 2019; Sovacool et al., 2017; Sovacool, Hook, et al., 2019; Sovacool, Kester, et al., 2019).

2.5.1. Distributive Justice

One of the primary justice dimensions of this inquiry is distributive justice since it constitutes the first step in assessing what would represent a just distribution, emphasising the unequal distribution of benefits and burdens. According to Rawls (1971), distributive justice involves the development of principles that inform the allocation of benefits and burdens. Specifically, there is a need to know how the revenue and burdens from oil and gas are distributed (Heffron, 2020), as well as understand other converging dimensions, for instance, vulnerability, need, and responsibility, entrenched in conventional environmental benefit or burden distributions (Walker, 2012; Williams & Doyon, 2019, 2020).

A few studies have focused on the uneven distribution of natural gas benefits, including gas flaring impacts (e.g., Bridge, 2009; Fry et al., 2015; Fry & Hilburn, 2020; Frynas & Buur, 2020; Watts, 2004), arguing that some host communities and people within gas flaring proximity, particularly affected majorly by oil and gas production and gas flaring, barely benefit from oil and gas revenues. Similarly, others (e.g., Cushing et al., 2020, 2021; Johnston et al., 2019, 2020) have examined US oil and gas production areas, finding that minority or lower-income rural communities undergo distributional injustices. Nigeria is the largest oil-producing country in Africa, with 37.0 billion barrels of proven crude oil and 200.4 trillion cubic feet (Tcf) or 5674.70 Bcm of proven natural gas reserves (EIA, 2020). However, studies have consistently shown high energy poverty levels in the country (Bombaerts et al., 2020; Chidebell-Emordi, 2015; Monyei et al., 2018; Nduka, 2021; Sanusi & Owoyele, 2016). Nigeria needs to improve access to electricity amid abundant natural gas energy resources that could help tackle the problem. Even in Canada (one of the most equitable countries in the world with high regulatory compliance, where there is an abundance of natural gas and large volumes of associated natural gas is flared), studies found that in 2017, energy poverty was patterned across a social, spatial gradient with between 6% and 19% of households living in energy poverty (Riva et al., 2021).

Distributive justice within gas flaring is thus focussed on addressing the uneven distribution of gas flaring impacts and aims for all people to have access to natural gas resources (Heffron, 2020). Additionally, distributive justice is centred on whether all populations have equitable access to green spaces, energy (electricity), clean air, and water and are not disproportionately impacted by gas flaring pollution or natural disasters.

2.5.2. Procedural Justice

Procedural justice focuses on institutional processes that create inequities (Lake, 1996; Schlosberg, 2004, 2009) and entails due process, representative and public participation, and process-oriented and deliberative democracy (Gutmann & Thompson, 2004; Sovacool & Dworkin, 2015; Weston, 2008). Procedural justice dimensions include access to information (transparency), participation (voice, representation), impartiality (unbiased), accessibility (access to a fair hearing), objectivity (merit and reasoned judgement) and respect (McLaren, 2002, 2012). These elements can influence the social legitimacy or acceptance of different energy technologies or policies and determine whether people have a voice and are heard in decision-making and whether procedural issues are handled respectfully, openly, and honestly (Evensen et al., 2018; Hull & Evensen, 2020).

Procedural injustice ensues when there is inequality, people are excluded from the decision-making and policy process, or when environmental information (e.g., gas flaring information) is deliberately unavailable. Accordingly, procedural justice involves democratic participation in decisions concerning costs and benefits ((Lake, 1996) and requires that affected people understand the significant threats a particular decision would inflict on them (Ottinger, 2013) through access to reliable information from reliable institutions (Malin, 2020). Connecting all the stakeholders involved in the gas flaring negotiation process is one of the complex challenges in the gas flaring system (Colombo et al., 2016). As such, non-meaningful participation in decision-making in planning and approving oil and gas projects in host communities such as the US (e.g., Ryder, 2018) and most gas flaring nations indicate procedural justice issues abound.

2.5.3. Recognition Justice

Recognition justice builds on the work of Fraser (1998, 2000, 2001) and Fraser et al. (2003) and advocates for tolerance and fair representation of vulnerable individuals or groups, including gas flaring host communities (Sovacool, Hook et al., 2019; Sovacool, Kester, et al., 2019). It focuses on issues of misrecognition or non-recognition of various groups and is closely associated with all types of prejudice and discrimination (e.g., Fraser, 1998; Fraser et al., 2003; Walker & Day, 2012). Misrecognition can occur in various forms, such as through cultural domination, non-recognition, or disrespect. It is often related to social categories like gender, race, religion, or ethnicity. State institutions may provide different levels of recognition to various groups, either explicitly or implicitly (Schlosberg, 2004, 2007; Walker, 2012).

Recognition injustice challenges has been integral to multiple conflicts and contestations, particularly in the global south, but also worldwide, particularly about outcomes for marginalised people, including (but not limited to) Indigenous communities (Hurlbert & Rayner, 2018). Within the energy sector, recognition justice has focused primarily on the impact of energy developments and activities on indigenous communities (McCauley et al., 2013). Specifically, when conceptualised narrowly within an energy justice and global gas flaring context, recognition justice is centred on whether the rights of different individuals or groups (host communities) are recognised where natural gas development and associated gas flaring occurs.

2.5.4. Cosmopolitan Justice

Cosmopolitan justice is inspired by the substantiveness and significance of obligations rather than minimal obligations, international obligations based on a proper institutional structure that unambiguously stipulates who is responsible for delivering environmental justice, and obligations premised on the human rights of others either violated or failed to be realised by the global economic system (Harris, 2008, 2011). Thus, cosmopolitan justice within the energy justice context requires a global and whole systems approach that examines developmental outcomes (Heffron & McCauley, 2017). Accordingly, cosmopolitan justice acknowledges that every human being has equal moral value and that responsibilities are not confined to borders, suggesting that ethical principles in distributive, procedural and recognition justice must be applied universally to every human being irrespective of nationality (Brock, 2009; Caney, 2005; Held, 2010; Pogge et al., 2008; Pogge, 1992; Sovacool, Hook, et al., 2019; Sovacool, Kester, et al., 2019).

Cosmopolitan justice necessitates a holistic global evaluation (spatiality and temporality) of energy or climate-related costs and externalities (Walker, 2009). This is because the impacts of human activities, including energy demand and supply and the business activities and processes required to create products or services, extend across borders due to global energy demands (Heffron, 2020). As gas flaring constitutes transboundary pollution and impacts climate change, it thus falls under the global justice tenet, based on cosmopolitan world ethics involving rights, duties, and ethical importance (Harris, 2011). It requires that ethical principles be applied universally to every human being, irrespective of nationality. It can further be conceptualised based on the premise that everybody is protected under global citizenship and has a right to a clean and safe environment, including people living in gas flaring host communities who have been neglected (Caney, 2005; Heffron, 2020).

2.6. A Whole System Approach

Systems thinking has been used in many fields to understand and tackle the complex behaviour of social, ecological, and economic systems. It believes that the behaviour of a system results from the interactions, feedback loops, and cause-and-effect relationships between its components (Checklan & Checkland, 1999; Fazey, 2010). Systems thinking is similar to holistic thinking in that it focuses on the dynamics of the entire system and the significance of the interactions between the parts in determining the whole system's behaviour.

Systems thinking focuses on analytical thinking and aims to enhance decision-making skills. According to Thibodeau et al. (2016), this approach is usually combined with a normative claim. This thesis applies an operational definition of systems thinking as a perception of the world that involves recognising the dynamic nature of systems, understanding the different levels of cause and effect, including indirect relationships between parts, and situating oneself within the system being studied (Clark et al., 2017).

The energy system, specifically the gas flaring system, is complex and encompasses the entire energy cycle, from mining and conversion to production, transmission, consumption, and waste (Alanne & Saari, 2006; Bevir, 2008; Gagnon et al., 2002). Such a socio-technical system comprises physical infrastructures and social elements, including user behaviour, lifestyles, values, and organisational structures (Liddell & Morris, 2010; Markard et al., 2012; Whitmarsh, 2012). To address the complexity of this system, the thesis proposes a systems approach that involves identifying the system's characteristics, examining its elements, interconnections, and overall function, and carefully examining the interactions between them.

Systems theory involves examining the multiple subsystems that work together to achieve specific objectives, such as reducing gas flaring. Specifically, the systems theory approach in gas flaring involves examining the interactions between different system elements to understand it better and identify potential areas for improvement. As such, the systems theory approach adopted in this thesis best captures the relational approach (Castán Broto & Baker, 2018), which considers a range of systemic questions relating to energy, geography, society, and the patterns of energy distribution and consumption. It also considers policy, management, and transboundary pollution (Dowlatabadi & Granger Morgan, 1993; Gibson et al., 2000). Systems theory helps to see the totalities, interrelationships, and patterns of gas flaring challenges and possible solutions. By adopting this approach, we can view gas flaring challenges and potential solutions as integrated systems rather than isolated parts and, in doing so, seek solutions that simultaneously address multiple problems (Anarow et al., 2003; Senge, 1991). Such an integrated framework brings forward governance and policy dimensions, including questions of justice, access, distribution, and the implications for space and territory (Castán Broto & Baker, 2018). It also focuses on how social, economic, political, and environmental factors interact across local, national, and global scales and levels.

Meadows (2008) emphasises the common practice of breaking down complex systems into smaller, more comprehensible parts, but this approach can be problematic when implemented on a national scale without proper consideration. Unfortunately, in some cases, our attempts at finding solutions may contribute to or overlook the negative consequences of activities, for example, the impacts of uranium mining on the environment and human health (Florini & Sovacool, 2009; Savacool et al., 2014). This thesis emphasises the importance of taking a global perspective when considering the impacts of our decisions on the environment (Stagl, 2006: 53). By looking at the bigger picture, we can identify potential problems and unintended consequences arising from our actions (Adams et al., 2013: 94), with the view that increasing awareness of human needs and actions can improve the overall system (Bevir, 2008: 202).

Transboundary pollution problems, such as global gas flaring, require analytical dimensions of spatial scales or the spatial, temporal, and quantitative at micro, meso, and macro levels (Gibson et al., 2000). Accordingly, policy and evaluation of, for instance, gas flaring and climate change issues necessitate a comprehensive examination of all elements. Such integrated assessment should also encompass different analytical approaches in addressing different parts of the problem, for example, Dowlatabadi & Granger Morgan's (1993) model framework for integrated studies of the climate problem. Changing the global gas flaring system requires adaptive governance congruent in scale and levels with environmental events and decisions (Young, 2002). Given the growing concern about issues including global gas flaring and broader climate change impacts, there has been a shift in the direction of meso- and macro-scale studies in geographic studies, fundamental and deeply rooted in the identification of patterns and their explanation at different scales (Gibson et al., 2000).

Following Cash et al. (2006) and Gibson et al. (2000), 'levels' are defined as the units of analysis that are located at different positions on a scale. Transboundary pollution problems can be measured at different levels and along multiple scales, meaning consideration of governance at all levels is essential. The systems thinking lens is employed here to examine global gas flaring issues with a particular emphasis on the local, national, and global levels that have received little attention in the literature. In chapter 3, objective 2, analyses of the Nigerian gas flaring case (local and national levels) is first compared with other gas flaring nations, as Nigeria is one of the top nations requiring aggressive flaring reduction mechanisms. Chapter 4 objective 3 analysed global gas flaring and energy justice across levels, identifying local and global injustices associated with flaring. Finally, chapter 5, objective 4 used a normative framework to optimise global gas flaring policies and regulations across the different levels.

Many scholars have taken a systems theory approach in analysing solar photovoltaic (PV) panels and exploring tensions between innovation and environmental justice (Mulvaney, 2013, 2014). Others have done so in energy justice analysis and transitions (Chien, 2022; Essletzbichler, 2012; Kanger & Sovacool, 2022; Miörner & Binz, 2021; Sovacool, Hook, et al., 2019) in urban residential landscapes and spatial planning systems (Chowdhury et al., 2011; Getimis, 2012); assessing smallholder adaptation and rural communities' capacity for resilience, adaptation, and transformation (Burnham & Ma, 2018; Singh-Peterson & Underhill, 2017); in developing an index for monitoring drought (Ali et al., 2017); and assessing extreme flooding in western Amazonia (Langill et al., 2022). This thesis also draws on Bridge et al.'s. (2013) analyses of the transitions field, recognising that low carbon transitions are geographically established processes expanding beyond national scale case analyses and thus have to be multilevel. Despite this vast body of previous work, systems theory has not been employed to analyse gas flaring problems globally.

Systems theory is relevant in this context as it involves analysing a group of subsystems that work together to achieve specific objectives, such as natural gas production (Bevir, 2009:202). The system is viewed as more than just physical infrastructure and processes; it is considered a socio-technological entity that reflects intricate human-technology interactions (Kern & Smith, 2008). This inductive interactionist approach seeks to understand better the connections and feedback between the different parts of the system and use that insight to improve the system. The concept emphasises the significance of the relationships between those in power and the public and identifies key opportunities to influence and direct the system.

While MLG, policy coherence, good governance, energy justice, and the optimisation of gas flaring policies and regulations predominantly involve normative concerns, the system approach used in this thesis focuses on integrating these concepts within a single framework. It remains congruent with efforts to achieve the overall targets of 2030 Zero Routine Flaring and Net Zero Emissions by 2050, which are important aspects of the transition to a low-carbon system. This thesis, therefore, combines MLG and policy coherence, good governance, and energy justice-normative analytical frameworks that demand an assessment of gas flaring policies and governance, the costs, benefits, burden, and procedures involved in gas flaring decisions, alternative approaches, and pathways at the local, national, and global levels. Although the systems approach is commonly employed in the current discourse on energy justice in modern literature (Berjawi et al., 2021; Jenkins et al., 2014; Kanger & Sovacool, 2022; Martiskainen et al., 2021), in global gas flaring research, there is a dearth of comprehensive system perspectives that consider overall energy systems and their significant environmental impacts.

2.7. Conclusion

Global gas flaring issues and impacts can be usefully assessed by using a whole systems approach that spans complex MLG, policies, good governance, and energy justice. To achieve the goal of zero routine flaring by 2030 and support the broader aim of zero emissions by 2050, it is essential to understand the interplay between the various governance levels that regulate gas flaring, policy issues, good governance, and energy justice concerns. Despite the growing popularity of these theoretical concepts, the global gas flaring literature has not fully addressed the diverse implications of gas flaring within the energy system. This chapter has examined the global gas flaring issue by analysing and connecting literature on MLG, policy coherence, good governance, and energy justice in a whole system framework. The chapter has argued for a reconceptualisation of global gas flaring that includes a systems approach, which can address critiques of scalar ambiguity and failures to account for actor diversity within the current MLG, environmental, and energy justice literature. By adopting a systems approach, we can better understand the connections and relationships within the global gas flaring system and prompt scholars to scrutinise the dynamics and relationships involved.

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Chapter 3

Gas flaring in Nigeria: A multi-level governance and policy coherence analysis

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Abstract

The unnecessary flaring of natural gas impacts public and environmental health, contributes to climate change and wastes fuel resources. Though reducing flaring is an emergent global environmental governance priority, progress has been slow. We assess gas flaring policy in the critical case of Nigeria through multilevel governance (MLG) structure. Our analysis assesses policy coherence (leading to progress in reaching shared goals) and divergence (creating tension and undermining progress) among sectors and institutional structures across the supranational, federal, state, and local government scales. A combined dataset of documents, stakeholder interviews and expert surveys is analysed using qualitative document analysis (QDA) and content analysis. We identify the principal actors involved, examine the extent of gas flaring awareness and policy coherence across multiple sectors/policy domains, and assess progress towards Nigeria's national intended contribution and national policy on climate change mitigation. We find that policy coherence around gas flaring, including efforts toward climate change mitigation, has been slowed by political partisanship, poor governance, lack of regulatory compliance, and policy conflict between environmental protection and economic development priorities. Nigeria urgently requires inclusive involvement of stakeholder voices across multiple sectors and scales of local/regional government, the strengthening of federal institutions, a re-evaluation of economic aspirations through revenue diversification, and leadership that can temper the power of International Oil Companies (IOCs) to exploit the complexity of the MLG structure. These actions would help the government in improving environmental justice outcomes for flaring-affected communities.

Keywords: Natural gas, Flaring, Venting, Implementation, Climate mitigation, Africa, Climate change

3.1. Introduction

Flaring of natural gas is common in oil and gas extractive industries, to relieve pressure within pipelines reducing explosion risk, reduce volatile organic compounds through combustion, or release waste products from chemical production processes. Flaring involves piping excess gas to a remote (elevated) location and burning the gas in the open air. Though ostensibly gas a matter of routine fossil fuel operations, flaring often occurs due to a lack of economic, regulatory, or technical barriers to developing gas markets and gas infrastructure or when it is not feasible to reinject associated gas back into the reservoir (Buzcu-Guven & Harriss, 2014; Elvidge et al., 2009; The World Bank Group, 2021). Flaring is an environmental management issue due to the release of multiple atmospheric pollutants – including carbon dioxide (CO_2), carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen oxide (NO_X), naphthalene, photochemical oxidants, and black carbon particulates (Gobo et al., 2009). Such pollutants detrimentally influence human and environmental health and generate social and economic externalities in affected communities (Osuoha & Fakutiju, 2017). The impacts of gas flaring as an environmental justice issue have been historically under-reported due in part to a paucity of measurement, reporting and regulation limited by accurate data. However, recent improvements in accuracy, granularity, and availability of remote sensing data on flaring activity (from AVHRR, DMSP-OLS, ATSR, Landsat, MODIS, Soumi-VIIRS and Sentinel-3 SLSTR) in the US and globally (Anejionu, 2019; Anejionu et al., 2015; Elvidge et al., 2013) allow improved scrutiny of oil and gas operations, allowing bad practices to be identified and ameliorated through improved environmental governance. Nevertheless, protecting vulnerable communities from gas flaring impacts remains a critical sustainable development challenge, particularly in regions where fossil fuel operations occur under conditions of low regulatory capacity and compliance. Analysis of policy responses to gas flaring activities is thus a key research priority for achieving just sustainable transitions in countries with high dependence on domestic oil and gas production for economic and social development. In this paper, we critically assess the policy landscape of Nigerian gas flaring operations.

Gas flaring is a growing area of environmental and cross-cutting policy importance. The need for a flaring reduction strategy was only recently recognised in global climate policy, despite initiatives to reduce fossil fuel extraction and processing emissions. The Global Gas Flaring Reduction Initiative (GGFR) was formally recognised in 2018 following the Paris Agreement and global commitments to keep warming levels below 1.5°C (UNFCCC, 2021). The top gas flaring countries (who are also signatories and active UNFCCC participants) have nevertheless struggled to abate flaring, in part due to the political power of fossil fuel industry lobbying efforts, and the fossil-fuel 'lock-in' that continues to dominate the economic interests of oil and gas producing nations. While most oil-producing countries have policies towards gas flaring regulation, implementation often differs due to varied policy structures, which in most cases are embedded in complex layers of governance from supranational environmental agreements down to regional and local tiers of environmental planning. Though flaring has become an increasingly visible policy issue globally, it is often addressed through voluntary agreements rather than top-down policy and coordinated action. It is therefore necessary to assess gas flaring policy through reference to a conceptual framework of multi-level governance (MLG) to understand the translation of voluntary environmental commitments to national-scale political action in practice, and the influence this has on domestic environmental justice to gas flaring-affected communities.

This paper considers the gas flaring policy in Nigeria. Nigeria is a critical case for such analysis because the continued operation of the oil and gas industry is central to the country's economic and social development strategy. Nigeria is the largest oil-producing country in Africa, with 37.0 billion barrels of proven crude oil and an even greater 190.4 trillion cubic feet (Tcf) of proven natural gas reserves. Fossil fuels account for >80% of government revenues, 95% of export receipts, and 90% of foreign exchange earnings (Oladele & Abdul-Azeez, 2013; Uwakonye et al., 2006; Watts, 2004). The Nigerian Government's utilisation of natural gas resources is a core aspect of its administrative operations. The government has instigated multiple public-private partnerships for gas development, including the Nigerian Liquified Natural Gas Company, and actively promotes inward investment (e.g., Chevron's Escravos Gas Utilization Project for liquified natural gas exports). There is also a strong commitment to social development through gas utilisation, improving policy strategy to improve national electricity access rates through gas-fired power station construction.

Though the national economic and social development strategy emphasises the productive use of gas resources, Nigeria wastes a lot of its resource, remaining in the top seven gas flaring countries globally. The estimated annual flare was 7.83-17.5 Billion cubic metres (Bcm) during 2010-2020 (The World Bank Group, 2021). Of the 53.6% total CO_2 emissions contributed by the energy sector in 2000, the Nigerian gas sector accounted for 40.3% (INDC-Federal Ministry of Environment, 2014, p. 3 and 37). Between 2010 and 2020, annual natural gas production was between 65.85 and 82.17 Bcm, while flaring was between 7.83 and 17.5 Bcm. During 2010-2019, Nigeria produced 750.33 Bcm of natural gas and flared 114.35 Bcm (13%), which, for context, could supply nearly two years of the UK's gas requirements. In 2019, the annual flare increased by 3% (39 million cubic metres (Mcm)) from that of 2018 (NNPC, 2020; The World Bank Group, 2021). Although flaring decreased 4.9 % in 2020, this was attributed to oil price plunges during the COVID-19 pandemic, which led to a corresponding decrease in global oil production. The economic cost of flaring is substantial, despite widely varying estimates. For example, Nigeria is estimated to lose 18.2 million U.S. dollars daily, while PWC estimated losses of 761.6 million U.S. dollars in 2018 from flaring ((OnlineNigeria.com, 2003; PWC, 2020), excluding the negative externalities, social, health and environmental harms experienced by residents of major sites of gas production.

From an environmental governance perspective, the situation in Nigeria remains paradoxical and environmentally unjust. Gas flaring was first declared illegal in Nigeria in 1984, though as Akinola (2018) argues, multinational fossil fuel extraction companies continued to treat compliance as a matter of convenience and not of necessity. This attitude has persisted, despite multiple policies, regulations, and legal frameworks relevant to gas flaring management at the federal level (Table 3.1).

Table 3.1. The historical legal frameworks relevant to gas flaring management at the federal level. Sources: (DPR.GOV.NG, 2021; GGFR-World Bank Group, 2004; NASS, 2020, 2021; NGFCP-DPR, 2021)

	Regulation	Year
1	Petroleum Industry Bill (PIB)	2021
2	Petroleum (Drilling & Production) (Amendments) Regulations	2020
3	Petroleum (Drilling and Production) (Amendment) Regulations	2019
4	Flare Gas (Prevention of Waste & Pollution) Regulations	2018
5	The Nigerian Gas Flare Commercialisation Programme (NGFCP)	2016
6	Petroleum (Drilling and Production (Amendment) Regulations	2006
7	Petroleum (Drilling and Production (Amendment) Regulations	2001
8	Petroleum (Amendment) Decree	1996
9	Environmental legislation-Effluent Limitation Regulations	1991
10	Petroleum (Amendment) Regulation	1989
11	Petroleum (Drilling and Production (Amendment) Regulations	1988
12	Associated Gas Reinjection (Continued Flaring of Gas) Regulations	1985
13	Associated Gas Re-Injection Act	1979
14	Petroleum Regulations	1967
15	Petroleum (Drilling and Production) Regulations	1969
16	Petroleum Act	1969

Through the Nigerian Gas Flare Commercialisation Programme (NGFCP), which was explicitly designed to implement the government's policy objectives to eliminate gas flaring, the Federal Government policy position appears to abate gas flaring while the Petroleum Industry Bill (PIB) provides legal, governance, regulatory and fiscal frameworks for the Nigerian petroleum industry, the development of host communities and for related matters (Amaza, 2018; NASS, 2020; NGFCP-DPR, 2021). At the international level, Nigeria ratified the Paris Climate Change Agreement in 2017 and is a signatory to the GGFR principles to end gas flaring by 2030. Correspondingly, Nigeria has committed to tackling climate change through its Intended Nationally Determined Contribution (INDC) and National Policy on Climate Change (NPCC).

Despite escalating policy commitments, flaring activity, particularly across the Niger Delta region, remains high (American Association for the Advancement of Science, 2011; Okeke, 2019). The Niger Delta constitutes 7.5% of the country's population and remains the most deeply affected region (Mafimisebi & Ogbonna, 2016). Managing trade-offs between fossil-fuel-based economic development and sustainable low-carbon social development remain deeply complex. Although Nigeria functions as a quasi-federalist democracy, the tightly controlled federal structure and personal rule of the presidency is backed by substantial military influence. This creates significant challenges to achieving social justice for the poorest fossil-fuel-producing regions (Ikpe, 2000; Leonard & Straus, 2003; Takehiko, 2010; Yagboyaju & Akinola, 2019; Yakubu, 2018). Collective legislative action on gas flaring has had minimal or no impact on the poorest Delta communities, meanwhile Nigeria continues to experience a relatively low level of economic development overall (Dartey-Baah et al., 2014; Donwa et al., 2015; Husted & Blanchard, 2018; Idemudia et al., 2010; Ncala, 2016; The US Department of Justice, 2019; Watts, 2004). Any justification of environmental harm to Delta-region residents through appeal to the greater public good of oil and gas development tax revenue generation and subsequent social development spending is therefore indefensible.

Though the problem of gas flaring in Nigeria is well documented, the contemporary political dynamics of gas flaring governance require further scrutiny, as international pressure to meet climate goals become salient aspects of donor support and aid funding, and pressure mounts from NGOs and environmental activists. We explore the problem through qualitative empirical analysis of gas flaring policy in the context of Nigeria's broader political and institutional structures, policy framework and socio-economic context. We employ multilevel governance (MLG) and policy coherence frameworks to explore how the relationships between different actor perspectives and institutional and policy frameworks operate across different policy sectors in Nigeria. Our research objectives are to:

1. Identify the main actors involved in Nigeria's MLG system pertaining to oil and gas governance
2. Examine the extent of gas flaring awareness and policy coherence across gas flaring and energy domains

3. Assess the implications for progress towards Nigeria's national intended contribution and national policy on climate change mitigation.

Our analysis provides insight into environmental governance best practices, through an assessment of policy coherence and implementation across multiple sectors and scales of governance, with recommendations for environmental policy globally.

3.2. Multi-level Governance and Policy Coherence

Multilevel governance (MLG), multi-tiered governance, polycentric governance, and fragmented governance are concepts variably used to describe changes to national, international, and supranational regimes (Eckerberg & Joas, 2004). Within MLG analysis, the emphasis lies upon the interaction of different actors and institutions across multiple scales of policy action, described by (Hooghe & Marks, 2001) as authority diffusion from the central government up to the supranational level, down to subnational jurisdictions and sideways across public/private networks. Hooghe and Marks (ibid.) identify two distinct visions: MLG Type I and MLG Type II. In Type I MLG, the dispersion of authority is relatively stable, with no jurisdictional overlap and limited levels. Type II MLG is a complex structure with jurisdictional overlaps and is usually situated within Type I jurisdictions. These jurisdictions are flexible, temporary, and characterised by their interchangeability.

Policy coherence implies a relationship and consistency between policy goals, policy instruments, implementation, and outcomes (Huttunen et al., 2014; Mickwitz et al., 2009). Coherence advances cooperation between and within complex policy domains to realise policy objectives that are collectively agreed upon and recognised (Nilsson et al., 2012). To facilitate the implementation of gas flaring policies, individual sectoral policies need to be consistent with one another. Of note is the coherence between policy domains pertaining to energy, economic development, and mitigation and adaptation to climate change. For example, policies that encourage energy export for economic growth, assuring local environmental and public health compliance, and growing tax revenue collection for domestic social development, may provide a package of self-reinforcing sustainable development objectives or else may produce internal conflict with one or more policy objectives undermining the achievement of the others. Conflicting goals and rules present significant challenges to policy coherence in an MLG system (Sandström et al., 2019). Understanding how MLG and policy coherence operate in concert is the subject of our empirical analysis.

3.3. Methodology

Our four-stage Qualitative Document Analysis QDA approach was used to undertake a horizontal-level policy coherence analysis. We follow a four-step QDA model (identified in Altheide, 2008), as described below:

1. Set the criteria for document selection
2. Select and obtain the relevant documents
3. Perform Qualitative Document Analysis (QDA)
4. Validate through interview and survey data collected from stakeholders within the sector.

Step 1. Setting the criteria for document selection

For the analysis of academic literature, a Google Scholar search was performed, combining the text words “gas flaring” AND/OR “gas venting, in Nigeria”, restricting the search to English language journal articles.

Official government policy documents were sampled. Inclusion criteria in selecting documents were those pertaining to: oil and gas – exploration, extraction or development and related sectors that provide reference to gas flaring; and climate change and greenhouse gas emission reduction strategies. The sampling frame covered publication years 2000-2020.

As some documents include oil spills and other environmental hazards, only segments related to gas flaring were considered. Key sectors contained within the sectoral adaptation and mitigation programmes were identified from the National Policy on Climate Change (NPCC) 2013 document.

Step 2. Select and obtain the relevant documents

Sectoral government policy documents were obtained through an internet search, combining the search terms "gas flaring policies and/or regulations" and/or "Nigeria policy documents" with subject headings "Nigeria gas flaring, and/or NDP and/or INDC, and/or climate change.

The corpus was restricted to English language publications. Relevant government websites displayed during the initial search were further searched to locate specific sector policies. Table 3.2 details the final documents obtained and selected for analysis.

Table 3.2. Documents that make up the sample for qualitative document analysis.

Sector	Policy Document Title	Year Published
Energy policy	National Energy Policy	2003
Climate Change	National Policy on Climate Change	2013
Intended Nationally Determined Contribution (INDC)	Nigeria's INDC	2015
Gas policy	National Gas Policy	2017
National Action Plan (NAP-SLCPs)	National Action Plan to reduce Short-Lived Climate Pollutants	2018
National Development Plans (NDP)	Nigeria- Economic Sustainability Plan	2020

Step 3. Qualitative document analysis

Systematic policy coherence analysis of the selected sectoral policy documents was performed across sectors. Documents were analysed using content analysis (e.g., England et al., 2018; Stemler, 2001) comprising four stages. The first stage (3a) involved counting and scoring each keyword. Each of the policy documents was assessed to ascertain language pertaining to gas flaring and venting, then its level of conceptual linkage to other policy domains, and the prevalence of mitigation strategies and measures contained within the policy framework. Data were coded thematically using NVivo software and utilised to locate each of the gas flaring concepts within the sector's policy documents for dominant strategies grouped into four main themes: (a) gas flaring and venting, (b) energy (c) national gas and energy inter-sector alignment for climate change mitigation (d) climate change mitigation. Each sector policy was reviewed, and the number of times each concept was mentioned was recorded. Keywords "natural gas", "flaring", "climate", "venting", "gas flaring", "climate change", "mitigation", and "climate mitigation and financing" were searched for within the documents. The semantic and discursive context of the gas flaring-related concepts within the sentence, phrase, or paragraph in which they appeared was then assessed.

In the second stage (3b), direct content analysis assessed the level of coherence of each policy document using the keywords to locate the sentence or paragraph where they were used within each policy document. This involved thorough reading of each document to ascertain the specific background context and insight into the government's strategies, particularly how these keywords were prioritised within the strategic plans. Keywords were then grouped and reorganised into themes based on relationships focusing on climate change policy strategies and INDC plans, facilitating cross-comparison.

The third stage (3c) involved checking for coherence using keywords. The number of times each of the keywords was mentioned formed the first part of assessing awareness regarding gas flaring. Each mention of the various gas flaring and venting-related concepts was assessed according to how they were used in the paragraph. Scores were applied to the level of coherence, ranging from 0 (no coherence) to 3 (high coherence) for each policy document concerning awareness of each of the nine gas flaring concepts and the extent of relevant strategies using a categorisation matrix (e.g., Elo & Kyngäs, 2008) (Table 3.3).

Table 3.3**.** Scoring criteria to assess coherence and their definitions. Adapted from (England et al., 2018; le Gouais & Wach, 2013).

Type of Coherence	**Description of Coherence**	**Score**
High Coherence	Policy document aligns strongly across national gas policy, energy, and climate change statements. Policy dedicates a specific attention to both gas flaring and venting mitigation and energy inter-sector alignment concerning climate mitigation. It includes a range of detailed complementary measures and plans to achieve coherence.	3
Partial Coherence	While the policy document supports both the national gas and energy inter-sector alignments in relation to climate change mitigation, inadequate details on associated measures are provided, and it is unclear how it could be achieved. Also, limited activities and plans are incorporated but lack comprehensive detail.	2
Limited Coherence	Policy document supports national gas and energy inter-sector alignment concerning climate mitigation (particularly in the form of general statements). However, no details on activities or plans are provided.	1
No Coherence	Policy document lacks evidence of coordination or alignment in sectoral statements.	0

The keywords were then used to search each policy document to assess how and to what extent they described the same issue. Average coherence scores were generated for the various documents.

The fourth stage (3d) considered the level of coherence between sectors. This involved careful review of each document to identify when each of the other sectors was either explicitly mentioned or implicitly considered by averaging the two values ascribed to each policy document as calculated in stage three.

Step 4. Validation and finalisation through qualitative interview and survey responses

Validation and finalisation (steps 3 and 4 of the QDA) comprised stakeholder interviews with actors involved in gas flaring, including climate change mitigation and adaptation action in Nigeria. Attempts were made to schedule interviews with the five federal institutions responsible for gas flaring management in Nigeria, but tight political controls meant participation was consistently declined. Furthermore, 30 individuals, employees of these federal ministries, institutions, and agencies who were contacted declined our invitation due to "instruction from the top" not to participate. Consequently, seven experts (four representatives from environmental NGOs and advocacy groups and three environmental campaigners) were interviewed, while an industry experts survey targeted people with a PhD in oil and gas and related fields and policy experts.

We employed purposive sampling to identify experts for the survey and utilised a snowball sampling technique to recruit the other experts. We contacted 59 experts through e-mail, and 23 replied and completed the survey. Interview and survey respondents' roles or connections with their organisations were anonymised. NVivo software was utilised in coding and analysing the validation data according to sectoral themes.

3.4. Results

First, we present key findings from our literature analysis of Nigeria's MLG system pertaining to oil and gas governance. Second, we show the extent of gas flaring awareness and policy coherence across the policies of different sectors, and finally, we examine the implications for progress towards Nigeria's INDC and NPCC.

3.4.1 Nigeria’s MLG System Pertaining to Oil and Gas Governance

Following independence from British colonial rule in 1960, Nigeria began operating as a federal government system. The Nigeria constitution of 1999, as amended, provides the basis for all laws and legislation at the highest level. Nigeria currently has 36 states, a federal capital territory (FCT) and 774 local government areas as a federation. States are not autonomous but depend on federal allocation and the 13% derivation from oil and gas-producing states (The Federal Government of Nigeria, 2008; World Bank, 2002). Vertically, the federation account's distribution is 48.50%, 26.72%, 20.60%, and 4.18% to the federal, state, and local governments and centrally controlled special fund (Ohiomu & Oluyemi, 2019; Suberu, 2019). On paper, Nigeria's governance structure is deeply rooted in federalism, relatively stable and with no jurisdictional overlap, with power-sharing amongst a limited number of authorities operating across three levels of governance (Federal, state, and local) (e.g., Hooghe and Marks, 2001 and Figure 3.1). In practice, diverse sectors and government agencies function under a tightly controlled centralised governance structure – this in turn a legacy of successive military dictatorships structuring the institutional fabric of Nigerian politics.

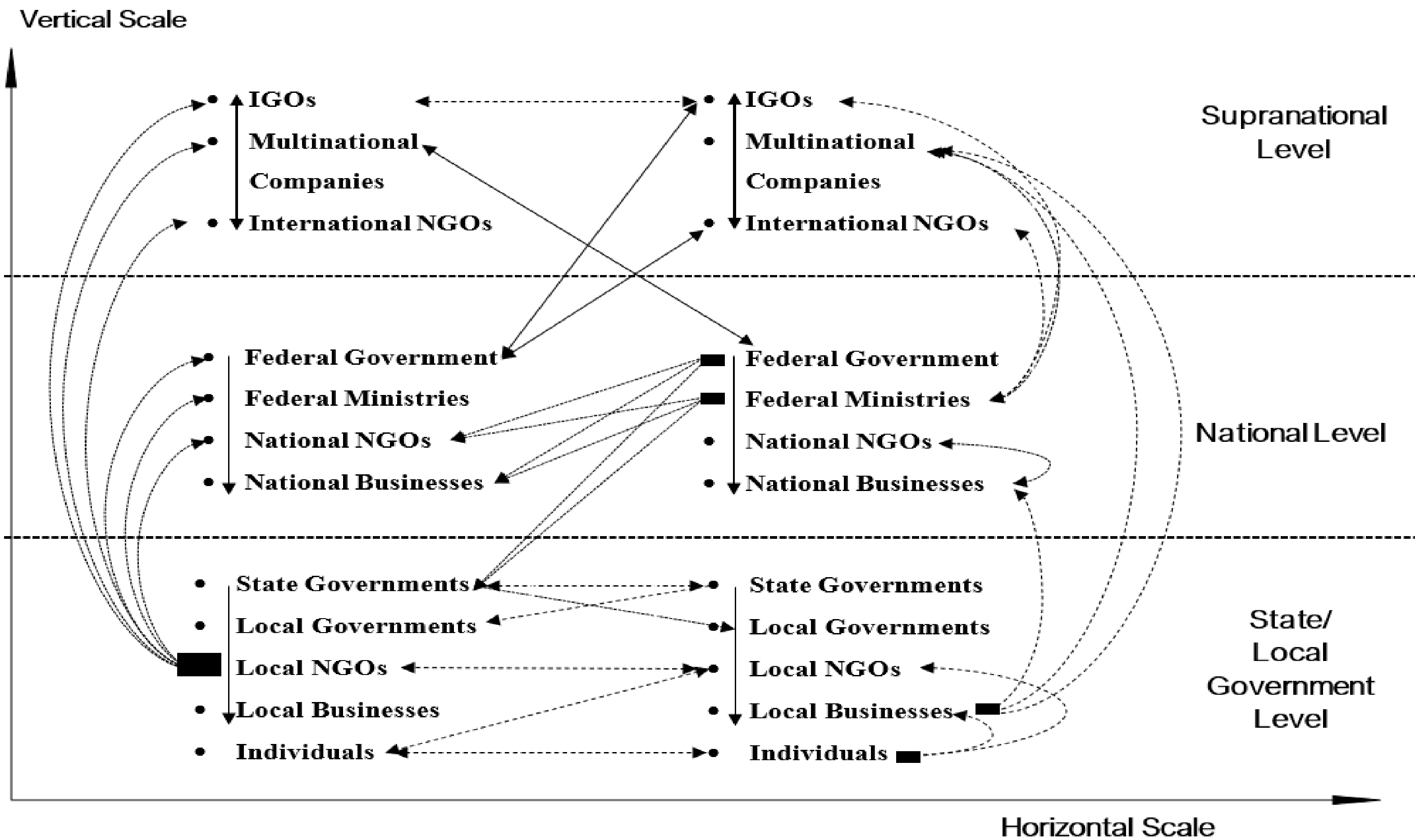

Figure 3.1. Horizontal and vertical dimensions of the Nigerian gas flaring management within a type II MLG system. Adapted from (Andonova & Mitchell, 2010, p. 258). Dotted arrows identify interactions where the action occurs involving many political actors operating across vertical and horizontal scales of jurisdictions, space, issues, and organisational domains. Abbreviations: IGO = Inter-Governmental Organisations; NGOs = Non-Governmental Organisations.

The Federal Ministry of Petroleum Resources (MPR) and Federal Ministry of Environment (FMEnv) are responsible for managing gas flaring and other environmental issues through parastatal organisations that wield indirect political authority (namely: the Department of Petroleum Resources (DPR), Nigerian National Petroleum Corporation (NNPC), and the National Environmental Standards and Regulations Enforcement Agency (NESREA)) (Figure 3.2). These federal institutions are responsible for formulating policies and regulations on environmental issues, including gas flaring. The historical context of Nigeria's gas flaring management is important because the parastatal organisational and administrative structure underpins Nigerian MLG and plays a principal role in policy implementation and public service delivery.

The first statutory agency established to regulate the petroleum industry was the DPR. In 1971, the Nigerian National Oil Corporation (NNOC) was established to manage the commercial and operational activities in the oil industry, while DPR under the Federal Ministry of Mines and Power exercised statutory guidance and industry control. The DPR was adapted into the Ministry of Petroleum and Energy in 1975 and later renamed the MPR. In 1977, the MPR and the NNOC were consolidated to create the NNPC. However, the petroleum inspectorate was still an integral component of the NNPC and was mandated to regulate the petroleum industry. The MPR was re-established in 1985, while the petroleum inspectorate remained within the NNPC. The NNPC was re-organised in 1988, and the petroleum inspectorate was moved to the MPR as the technical division and renamed the DPR (DPR, 2020; FMEnv, 2020; MPR, 2019; NESREA, 2020; NNPC, 2020; Olawuyi, 2015; Otiotio, 2013).

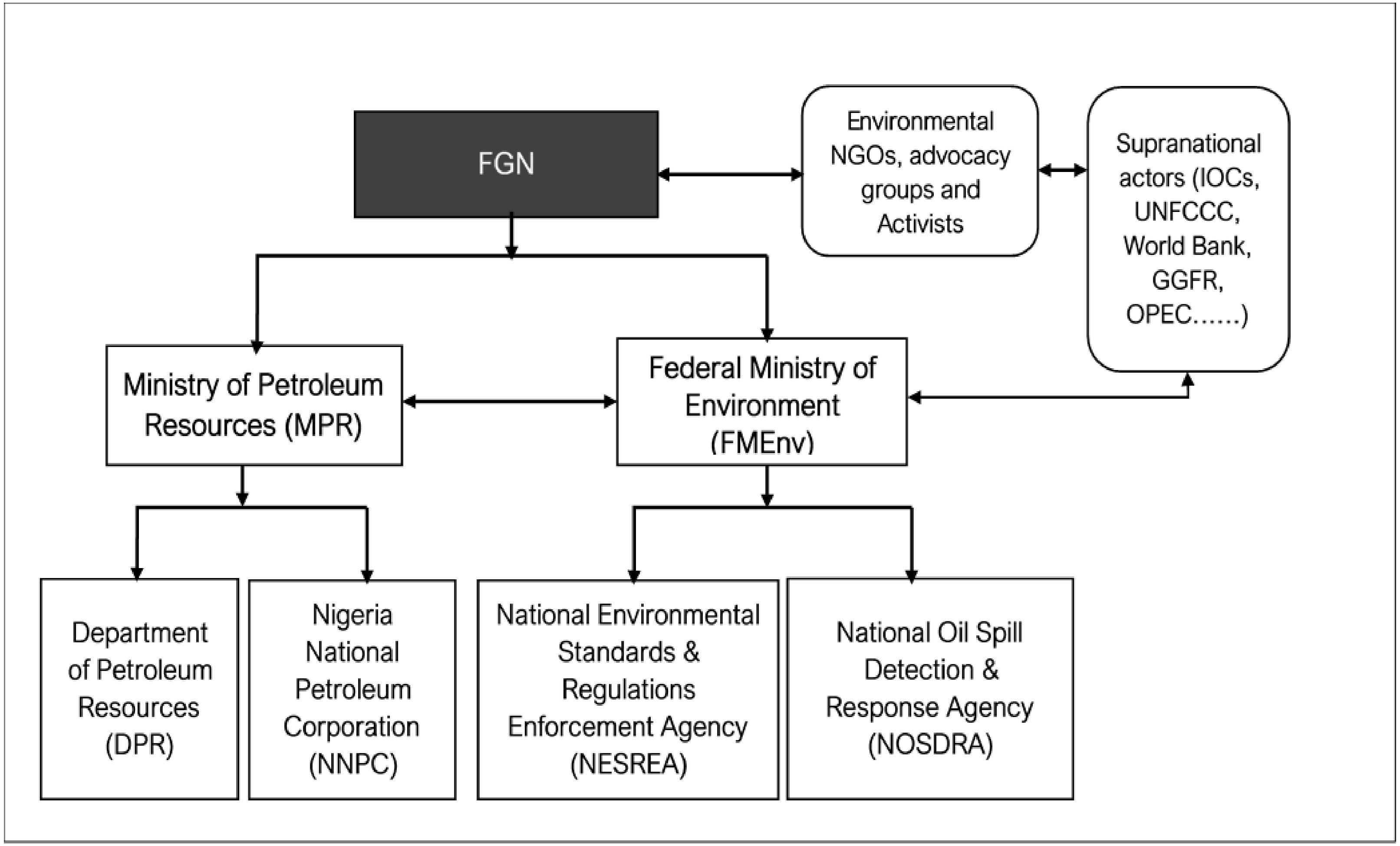

Figure 3.2**.** Federal institutions, environmental NGOs, advocacy, activists, and supranational actors involved in gas flaring and venting. FGN-Federal Government of Nigeria.

The MPR is the main federal executive organ responsible for articulating and implementing petroleum resources policies, maintaining standards, monitoring quality and quantity, and regulating industry practices. The minister has discretionary powers to grant flaring. The DPR and the NNPC are parastatals under the MPR. Through the MPR, the DPR is responsible for overseeing all the activities of all companies engaged in oil and gas production. It ensures and facilitates compliance with the applicable laws and regulations, including enforcement of safety and environmental regulations, and advises the government and relevant agencies on technical and policy issues (MPR, 2019; DPR, 2020; NNPC, 2020).

The Federal Ministry of Environment (FMEnv) was established in 1999 to protect and improve Nigeria's water, forest, land, and air by formulating, coordinating, and implementing environmental policies and programmes, prescribing standards, and formulating and enforcing environmental regulations and laws. NESREA and the National Oil Spill Detection & Response Agency (NOSDRA) are parastatals under the FMEnv. NESREA was established by the NESREA Act of 2007 and empowered to enforce all environmental laws, guidelines, policies, standards, and regulations and ensure compliance with international treaties, conventions, protocols, and environmental agreements (MPR, 2019; DPR, 2020; FMEnv, 2020; NESREA, 2020).

International oil companies (IOCs) and organisations such as the United Nations Framework Convention on Climate Change (UNFCCC), World Bank, GGFR and OPEC are also involved in gas flaring management. However, power is unevenly distributed across the governance system. Though several different parastatal organisations are involved in shaping the overall gas flaring management structure in Nigeria, political power still follows the conventional top-down quasi-federal structure. Analysis of the expert survey data indicated that 45% of those surveyed considered that the IOCs weaken policy implementation due to their influence on government policies to help them align with their business goals, while the 36% who agreed that the IOCs strengthen policy implementation were mainly working in technical fields (engineering) and employees of the IOCs. The remainder considered the influence of the IOCs has a neutral influence on gas flaring policy implementation. Interviewees underscored these findings. One respondent stated:

> *I have described the oil companies in Nigeria as a country within a country. The oil companies are high key players in the politics of Nigeria and the economy of Nigeria. The*

oil companies do work together with the federal government (Environmental Campaigner 3).

A second respondent noted that:

If you tell Shell to stop flaring today, then there is no need to produce oil then. The oil companies know that Nigeria's government is not ready to stop gas flaring (NGO representative 4).

The first factor that shapes the Nigerian MLG structure is the amended 1999 Constitution. The Nigerian governance structure operates within a Type II MLG system, and its structure has created loopholes, overlapping policy domains, fragmentation, and enclaving ("a country within a country") whereby extractive industries operate in a self-governing manner outside of national regulatory jurisdiction (Ackah-Baidoo, 2012). The federal government formulates and implements gas flaring policy, but the role of non-state organisations (specifically IOCs) creates the conditions for a complex type II MLG structure (Ikpe, 2000; Yagboyaju & Akinola, 2019; Yakubu, 2018). Notwithstanding, under Part II of the Nigeria constitution, section 4 (1) Subsection 3 vested the legislative powers of the Federal Republic of Nigeria in the National Assembly to make laws for the Federation concerning any matter included in the exclusive legislative list. That provision makes it extremely difficult for the regional state and local governments to interact directly with the federal government, including on issues concerning gas flaring, even though the pollution caused occurs primarily within the various states' jurisdiction within the Niger Delta. States have little or no power to control gas flaring because the policy issue belongs to the exclusive list. Therefore, they are reliant upon federal-scale top-down policy implementation and enforcement through parastatal actors and hence lack a 'voice' in the processes of good environmental governance (World Bank, 2002; The Federal Government of Nigeria, 2008).

The second factor that shapes MLG is legislative change. The Federal Government has introduced various plans for new laws on gas flaring. At the federal level, all the hydrocarbon legislation (Aye & Wingate, 2019; Udok and Akpan, 2017; The World Bank Group, 2004) is relevant to gas flaring management in Nigeria. Although these laws were introduced to mitigate gas flaring and venting, no proper consultation or discussion with interested parties was considered since there is a reoccurring concern of low stakeholder engagement in Nigeria's oil and gas management (Ayotunde, 2016; Emoyan, 2010; Enuoh, 2015), particularly of state governments and host communities. Hence, on paper, these laws may have been carefully formulated, as numerous interviewees noted:

> *One thing is wanting to have a policy, and it is another thing if you genuinely want the policy to work"* (NGO representative 3).

> *The fact that these agencies exist does not necessarily mean that they are effective. DPR is controlled at the federal level. Individuals who own oil wells and oil companies mostly are not from the region"* (Environmental Campaigner 3).

Validating the complex and fragmented Type II MLG system (Figure 3.2) with unclear leadership in the various authorities concerned with gas flaring management, analysis of the expert survey data indicated that 23% of those surveyed agreed that the local and state government priorities and politics concerning flaring match those of the national government, 45% considered that they do not match, while 32% answered ‘unsure’. Interviewees underscored these findings:

> *To the best of my knowledge, I do not think that Federal Government involves all the possible stakeholders in gas flaring and in deciding whether to flare. It is usually the Federal Government, IOCs, and other companies that sit down and discourse and come up with rules of flaring* (Environmental Campaigner 2).

> *There is hardly any involvement, and it is the lack of involvement that has led us to where we are today, the agitation, the activism in the region to complain about gas flaring to complain about, about injustice* (Environmental Campaigner 3).

We further asked survey respondents how well they consider policy goals and stakeholder preferences fit together. Again, 45% said that the policy goals and preferences do not fit together, 20% considered that they do fit, and 35% were undecided.

The third factor shaping MLG and, subsequently, policy coherence and implementation is the administrative structures (Figures 3.1 and 3.2). Sectors and government agencies function under a tightly controlled governance structure, but Federal institutions and agencies tasked with gas flaring management lack the autonomy to function effectively as monitoring and reporting bodies (Ako & Olawuyi, 2017). At the federal level, restructuring of ministries and government agencies across electoral cycles every four years has created barriers to long-lasting policy commitments (Fourchard, 2011; Kolawole, 2020; Zovighian, 2018). One interviewee noted:

There have been different governments. This one comes in, changes policies, and even within the same government, you have a somersault in policies. We have not had any strategic push to develop a plan (Environmental Campaigner 2).

The federal government also exercises strict political control over ministries/institutions and parastatal agencies located in the political centre in Abuja. However, the physical distance (Abuja and the Niger Delta region is approximately 550 km apart) creates a political geography whereby the federal capital territory positions the Niger Delta region as a sacrifice zone to meet other national policy goals (De Souza, 2021; Ogwu, 2012; Unah & Iruoma, 2021). As an interviewee noted:

The government concentrates power in Abuja, very far away from where solutions need to be. Until we diversify and see the need for other economic sectors to boost our economy, the people of the Niger Delta region or where the oil is being extracted from will become the sacrificial lamb (NGO representative 4).

3.4.2. Gas Flaring Awareness

Table 3.4 summarises awareness of gas flaring, venting and related concepts. Despite overlaps between, for example, natural gas, flaring, and gas flaring, the coherence scores of each concept were equally weighted for this research. Across the policies analysed, eight gas flaring and venting-related concepts were identified to generate the themes in the analysis. Notably, none of the documents analysed mentioned venting. The National Action Plan to reduce Short-Lived Climate Pollutants (NAP-SLCPs, 2018) and Intended Nationally Determined Contribution INDC (2015) documents demonstrated the highest level of awareness, with scores of 2.6 and 2.4, respectively.

Table 3.4. Coherence of policy documents and relevant keywords relating to gas flaring and venting concepts (coherence score 0–3).

	National Energy Policy 2003	National Policy on Climate Change 2013	Nationally Determined Contribution 2015	National Gas Policy 2017	National Action Plan (NAP-SLCPs) 2018	National Economic Sustainability Plan 2020
Natural Gas (Score)	28 Mentions (3)	3 Mentions (1)	5 Mentions (2)	55 Mentions (3)	26 Mentions (3)	6 Mentions (2)
Flaring (Score)	15 Mentions (3)	3 Mentions (1)	13 Mentions (3)	86 Mentions (3)	67 Mentions (3)	1 Mention (1)
Climate (Score)	2 Mentions (0)	81 Mentions (3)	12Mentions (3)	3Mentions (1)	172 Mentions (3)	0 Mention (0)
Venting (Score)	0 Mention (0)	0 Mention (0)	0 Mention (0)	0 Mention (0)	0Mention (0)	0 Mention (0
Gas Flaring (Score)	Mentions (3)	3 Mentions (2)	7 Mentions (2)	27 Mentions (3)	46 Mentions (3)	1 Mention (1)
Climate Change (Score)	0 Mention (0)	69 Mentions (3)	86 Mentions (3)	2 Mentions (1)	57 Mentions (3)	0 Mention (0)
Mitigation (Score)	5 Mentions (1)	23 Mentions (3)	31 Mentions (3)	1 Mention (0)	66 Mentions (3)	3 Mentions (0)
Climate Mitigation & Financing (Score)	0 Mention (0)	4 Mentions (2)	9 Mentions (3)	0 Mention (0)	6 Mentions (3)	22 Mentions (0)
Mean Score	**1.3**	**1.9**	**2.4**	**1.4**	**2.6**	**0.5**

3.4.3. Policy Coherence Across Sectors

The National Gas Policy (2017) recognises gas flaring, including its mitigation strategies. The document proposed a clear policy, institutional, legal, and regulatory framework, including gas policy; gas legislation; regulatory authority; secondary legislation (regulation) to end gas flaring and address environmental issues. The National Energy Policy (2003) is old but still the most recent energy policy and details gas flaring, including mitigation strategies. The document proposed several strategies to eliminate the flaring of associated gas by 2008 by encouraging oil-producing companies to gather and utilise associated gas and imposing appropriate and effective penalties to discourage gas flaring. The most frequently mentioned strategies for gas flaring mitigation in the energy policy document include gas utilisation, flaring penalties, gas infrastructure, incentives, governance, and regulations. The same issues identified in the 2003 policy were repeated in other documents. For example, one of the energy policy objectives was "*To eliminate the flaring of associated gas by 2008"* (NEP, 2003). NPCC (2013 p. 2) noted the importance of: "*…supporting ongoing initiatives to gradually eliminate gas flaring".* The Nigeria Economic Sustainability Plan 2020 is the current National Development Plan (NDP, 2020) anchored in Vision 20:2020: The Federal Government's economic growth plan and the Nigeria Economic Transformation Blueprint (2009). Although the NDP is a developmental document that should emphasise sectoral strategies, it provided no evidence of a link between flaring policy and climate change mitigation action. However, it does mention The National Gas Flare Commercialisation Programme, although this has not yet commenced.

While the NPCC recognises gas flaring and detailed strategies, there were instances where the importance of inter-sectoral linkages to achieve mitigation were included. Several gas flaring and energy mitigation strategies were identified in both INDC and NDP documents. The NAP-SLCPs (2018) detailed abatement measures to eliminate gas flaring by 2020, explicitly stating that ''*Elimination of gas flaring and recovery and utilization of vented associated gas''* (NAP-SLCPs, 2018 p. 51) was of high priority within measures linked to the NGFCP document's current plans. However, the NGFCP is yet to start in 2021. Despite gas flaring and energy sectoral policies being mentioned in most of the documents analysed, detailed strategies were presented in the NAP-SLCPs and INDC documents. The INDC also mentioned: "*…work towards ending gas flaring by 2030*" (INDC, 2015, p. 2). The National Gas Policy (2017) stated that: "*The commercialisation of flared gas for supply into the domestic market is a high priority strategy for the Government in achieving the national mandate for flare-out by 2020*" (NGP-MPR, 2017, p. 62), while the NAP-SLCPs (2018, p. vi): aspired to see: "*100% of gas flaring* *eliminated by 2020*". These objectives clearly commit to a sequential reduction in flaring, though in practice, there has been an increase (NNPC, 2020; The World Bank Group, 2021).

In terms of the coherence of documents around climate change mitigation across sectors, the NPCC (2013), NAP-SLCPs (2018) and INDC (2015) scored the highest, each with a coherence score of 3 (Table 3.5). When considering the extent of coherence in national policies across gas and energy sectors and with climate change mitigation goals outlined in national policy on climate change, results indicate the NAP-SLCPs (2018) is most coherent with a mean score of 2.75 while NPCC (2013) and INDC (2015) both scoring 2.5. Other documents analysed fall between limited and partial coherence. Newer versions of each policy are not incremental iterations of the previous version, possibly due to the need to use the document to secure international funding, as was found in Malawi by (England et al., 2018). For example, whilst the original vision and mission statement of the national gas policy centred primarily upon economic derivatives, both the 2014 and 2015 INDC reports emphasised the need for international finance as a prerequisite to achieving the INDC plans. The National Gas Policy (2017, p. 32) seeks to: "…be an attractive gas-based industrial nation… […] ... and developing a significant presence in international markets" and to "…move Nigeria from a crude oil export-based economy to an attractive oil and gas-based industrial economy". Similarly, the INDC (2014, p.5-6) notes that: "Unfortunately, the economic situation of the country Nigeria makes it challenging for the government to allocate sufficient funds for climate change programmes... […] …International finance and investment, technology and capacity-building will be needed to achieve the ambitious intended contribution".

Table 3.5. Coherence of policy documents for key themes and adaptation keywords (score 3 = high coherence; 2 = partial coherence; 1 = limited coherence; 0 = No coherence)

	National Energy Policy 2003	National Policy on Climate Change 2013	Nationally Determined Contribution 2015	National Gas Policy 2017	National Action Plan (NAP-SLCPs) 2018	National Economic Sustainability Plan 2020
Gas Flaring	Details gas flaring and includes mitigation strategies. But no mention of venting throughout the document. (2)	Recognise gas flaring but no mention of venting throughout the document. But no details on associated mitigation measures Provided. (1)	Details gas flaring and includes mitigation strategies. But no mention of venting throughout the document. (2)	Details gas flaring and includes mitigation strategies. But no mention of venting throughout the document. (2)	Details gas flaring and includes mitigation strategies. But no mention of venting throughout the document. (2)	Recognise gas flaring. However, no details on associated mitigation measures provided. (1)
Energy	**N/A**	Policy recognises climate change variability with detailed strategies with prioritisation.	Policy recognises the importance of energy in mitigation climate change. Detailed Strategies with prioritisation.	Policy recognises gas flaring and includes mitigation strategies. But no mention of venting throughout the document.	Policy recognises the importance of improved energy efficiency in climate change mitigation.	Policy recognises the importance of the energy sector with few details and strategies included.

		(3)	(3)	(2)	(3)	(2)
National Gas, and Energy Inter-sector Alignment For Climate Change Mitigation	Document recognises gas flaring inter-linkage and provided some strategies to achieve integration. (2)	Document recognises the importance of inter-sector linkages and includes a number of approaches to achieve integration. (3)	Document recognise importance of inter-sector linkages and includes a number of approaches to achieve integration (2)	No explicit reference to inter-sector alignment. Few references plans to establish linkages. (0)	Document recognises the importance of inter-sector linkages and includes detailed associated strategies. (3)	General statement of inter-sector linkage but no mention of associated strategies. (1)
Climate change Mitigation	Few evidence suggesting climate change mitigation. (1)	Detail potential climate change and a few specific mitigation strategies. (3)	Details potential Climate change and several specific mitigations strategies. (3)	No evidence suggesting climate change mitigation strategies included. (0)	Details potential about climate change mitigation strategies (3)	No evidence suggesting Climate Change Mitigation awareness. (0)

Mean Score	**1.3**	**2.5**	**2.5**	**1.0**	**2.75**	**1.0**

Scoring criteria to assess coherence. Adapted from Le Gouais and Wach (2013); and England et al. (2018). Coherence=3: The policy document shows a high level of awareness of gas flaring and venting concept. The document gives specific attention to gas flaring and venting. It includes various and comprehensive complementary measures. Partial coherence = 2: The policy document shows general awareness of gas flaring and venting. Despite recognising the importance of gas flaring, however, there are few details and measures included within the policy document. Limited coherence 1: The policy document recognises gas flaring and venting. However, no details on associated measures are provided. There is no coherence=0: There is no evidence in the policy document to suggest gas flaring.

Assessment of the coherence of policies relative to one another revealed the highest scores for the NAP-SLCPs (1.84), NPCC (1.75), and INDC (1.75). However, the highest possible score was 3, indicating that the level of coherence concerning gas flaring in sectoral policies is between limited and partial coherence (Table 3.6). Expert survey findings validated this. All respondents agreed that incoherent policies and inconsistent as well as conflicting regulatory frameworks were problematic, with implementation challenges marred by corruption and poor governance. Of the 23 respondents, 67% considered incoherent policies might create difficulties in executing the gas flaring reduction strategy, and 59% strongly agreed that an inconsistent and conflicting regulatory framework might create difficulties in executing the gas flaring reduction strategy.

Table 3.6. Coherence of policy documents (3 = high coherence; 2 = partial coherence; 1 = limited coherence; 0 =No coherence

	National Energy Policy 2003	National Policy on Climate Change 2013	Nationally Deter-mined Contribution 2015	National Gas Policy2017	National Action (NAP-SLCPs) Plan 2018	National Economic Sustainability Plan 2020	**Total**
National Energy Policy 2003	**NA**	1.88	1.88	1.13	2.00	1.13	**1.34**
National Policy on Climate Change 2013	1.88	**NA**	2.50	1.75	2.63	1.75	**1.75**
Nigeria's INDC 2015	1.88	2.50	**NA**	1.75	2.63	1.75	**1.75**
National Gas Policy 2017	1.13	1.75	1.75	**NA**	1.88	1.00	**1.25**
National Action Plan (NAP- SLCPs) 2018	2.00	2.63	2.63	1.88	**NA**	1.88	**1.84**
National Economic Sustainability Plan 2020	1.13	1.75	1.75	1.00	1.88	**NA**	**1.25**
Mean Score	**1.34**	**1.75**	**1.75**	**1.25**	**1.84**	**1.25**	**9.18**

3.4.4. Implications for Progress Towards Nigeria's National Intended Contribution and National Policy on Climate Change Mitigation

Despite climate change mitigation being mentioned once and recognised in general statements in the National Gas Policy (2017), there was little detail concerning gas utilisation as a climate change mitigation strategy. However, specific details of intended measures and detailed strategies describing climate change mitigation were included in the NPCC, INDC and NAP-SLCPs. The National Energy Policy (2003) mentioned mitigation five times, though with little detail on strategy or implementation. Most of the mitigation measures in the national gas policy and energy policy documents were replicated in the INDC and NAP-SLCPs. For example, the national gas policy (NGP-MPR, 2017) stated that the country would: *"End gas flaring and address environmental issues".* The same measure was found in the National Energy Policy (NEP, 2003), which strived to: "*…eliminate the flaring of associated gas by 2008"* and (NAP-SLCPs, 2018) sought: "*…elimination of gas flaring" and "100% of gas flaring eliminated by 2020".* Whilst mitigation was mentioned three times in the NDP document, it was in the context of economic goals to: *"mitigate the effects of a deep recession".* This raises questions about whether the government is genuinely committed to ending gas flaring due to the economic benefits from oil and gas revenues, hence, the repeated extension of the target date. Expert survey data indicated that 53% agreed that economic policies dominate environmental policies and gas flaring concerns; 33% disagreed, and 14% were undecided. Interviewee responses corroborated this, for example:

> *The Nigerian economy is driven by an economic goal, with 90% of foreign earnings coming from oil and gas, while the government's attention is more focused on the economic benefits (earnings of that sector) than the environment. From what I see on the ground, economic derivatives or benefits weigh higher in the ranking of government interest than how the people feel. Hence, the Federal Government refused to sign the Petroleum Bill, and they kept shifting the goalpost* (NGO representative 3).

Despite detailing the policy relevance of climate change and several specific mitigation strategies in the INDC, NPCC and NAP-SLCPs, it is unclear how such strategies can be achieved in practice within the entrenched fossil capitalist economic model in Nigeria. Climate change concepts in policy documentation may therefore be used to secure international climate finance funding rather than reflecting a desire for serious economic transformation. For example, the (INDC, 2015) stated that Nigeria would: "Work towards ending gas flaring by 2030". However, the NAP-SLCPs (2018) stated that 100% of gas flaring would be eliminated by 2020. Repeated shifting of the target dates makes overall goals unclear and appears to override any progress recorded towards Nigeria's INDC and national policy on climate change mitigation while exacerbating the violent conflicts attributed to the ostensibly visible environmental injustices in the Niger Delta (Ako & Olawuyi, 2017; Gonzalez, 2016).

3.5. Discussion and Conclusion

This study shows that the main actors involved in Nigeria's MLG system pertaining to oil and gas governance operate under a fragmented Type II MLG structure with unclear leadership in the various authorities concerned within a tightly controlled and top-down quasi-federal governance regime. The lack of political will to end gas flaring (Akinola & Wissink, 2018; Benson, 2020; Iornumbe, 2019; Olujobi, 2020) is also attributed to the Federal Government's and other stakeholders continued economic interest in fossil fuel extractivism.

Nigerian energy and environmental politics are incremental rather than transformative due to the challenges of partisan federal politics. The current and successive military government regimes are characterised by dictatorship, rent-seeking and corruption and personal rule. These factors concentrate political power in Abuja in a 'top-down' policy framework, failing to address environmental injustices in the Niger Delta. Political elites insufficiently recognise the adverse impacts of gas flaring suffered by host communities yet continue to benefit from gas production. The concentration of political power further diminishes state governors' capacities to influence gas flaring outcomes from within the fragmented MLG Type II system. Quasi-federalism restricts regional/state stakeholders from speaking to legislative change, removing their political voice (Ako & Olawuyi, 2017; Gonzalez, 2016) as their power as heads of the federating units within their state's jurisdictions are curtailed. This situation has also made it expedient for the government to coerce individuals and heads of government's institutions/agencies to guarantee policies cohere across sectors on paper, even though the implementation impacts of environmental regulation are weak.

Government ministry and agency restructuring across electoral cycles every four years has created barriers to long-lasting policy commitments, leading to "somersault policies". Also, the federal government's strict political control over ministries/institutions and parastatal agencies allows the federal capital territory to position the Niger Delta region as a *sacrifice zone* (De Souza, 2021; Ogwu, 2012; Unah & Iruoma, 2021) to meet other national policy as well as personal and partisan policy goals. These influences strongly shape the MLG structure and policy coherence, resulting in a lack of coordinated action and political will to end gas flaring.

Analysis of Nigeria's INDC and policy on climate change mitigation suggests policy coherence is driven by a need to secure international climate finance. The Federal Government's heavy involvement in gas flaring management is contextualised by continued economic interest in maintaining the status quo within the gas sector, with environmental performance a subsidiary concern to wealth generation. This creates an implementation gap between the legislation on flaring and the enforcement of environmental protection measures that would adversely impact the IOCs and, by extension, the Federal Government. Relevant regional and state-level authorities and stakeholders remain excluded from decision-making, whilst those charged with enforcement are hesitant to carry out their respective functions relating to gas flaring management and regulatory practice. Although the Federal Government instituted the NGFCP in 2016 to end gas flaring, it faces additional concerns that may fugrther widen the implementation gap: the deliver-or-pay agreements (a requirement by licensees to guarantee the production of definite volumes of gas and be liable to pay or compensate for any shortfall where the contracted volume cannot meet the requirements); the rights of contractors under Production Sharing Contracts (PSC) with the NNPC joint ventures; the exclusion of benefits for some critical stakeholders with the largest investments (the oil companies) from the NGFCP programme; and the huge investments required to develop new infrastructure for flare gas collection and supply (Amaza, 2018; NGFCP-DPR, 2021). Although 200 bidders from 800 bids have been shortlisted, the initiative's economic benefits cannot be evaluated currently as the project is yet to commence formally. The implementation gap thus underscores five principal concerns summarised in Table 3.7.

Table 3.7**.** A summary of concerns and lack of action.

1. The implementation of gas flaring reduction suffers from policy incoherence from successive goal conflicts where gas flaring and other environmental and climate change mitigation policies give way to economic goals. While the Federal Government exerts tight control across the institutions and agencies, the federal institutions involved with gas flaring do not have sufficient autonomy over gas flaring regulation enforcement to hold the national authorities and other federal ministries accountable.
2. There is a lack of coordinated horizontal gas flaring and climate change mitigation governance and policy processes across all sectors. The analysis of sectoral policy documents presents a viewpoint on the need for more comprehensive collaboration and coordination among the actors concerned with its development. Also, the coherence levels across the sectoral documents indicate a need to create awareness and the importance of consistent policy alignment. This could, however, be realised through organised consultation at the horizontal level.
3. The Federal Government has consistently extended the target date to end gas flaring due to economic interest, profits derivatives by the IOCs, and economic and personal gains of both the political elites and the lawmakers who regulate and equally control a considerable number of the oil blocks. As Nigeria is heavily dependent on the revenue from oil and gas, any policy that would discourage oil and gas production is deliberately suppressed by the government, lawmakers, and the IOCs who benefit massively from continued oil and gas production and gas flaring.
4. The Nigerian gas flaring management structure lacks participatory processes. Although there may be stakeholder involvement in gas flaring and venting on paper, local host communities and state governments do not participate in gas flaring management.
5. The contradictory role of the NNPC, a parastatal under the Ministry of Petroleum Resources, as a majority shareholder in the joint venture (JV) production sharing contracts (PSC) weakens the potential of the government to monitor, measure and enforce gas flaring regulations.

Experiences drawn from a global overview of regulatory practices on gas flaring and venting with relevant lessons and conclusions from international experience and best practices on flaring reduction could prove informative (The World Bank-GGFR, 2004). Greater alignment of regulation of gas flaring is possible if greater cross-compliance between competing objectives can be achieved. Global-scale institutional mechanisms such as the Paris Agreement ((Erickson and Brase, 2019), through the INDC to the global response to climate change, could potentially provide a coordinating approach, even though the institutional landscape at a national level in Nigeria remains complex and evolving. While gas flaring under the PIB is centred around fines under the Act, the economic benefits of NGFCP and PIB cannot be evaluated currently as the current legislation items are yet to formally commence (NASS, 2021; NGFCP-DPR, 2021). Therefore, although the INDC emphasises voluntary emissions reduction, it could lead to higher ambition in mitigation actions and promote sustainable development.

As unclear power structures within the Nigerian complex MLG system and the lack of policy coherence across sectors negatively influence gas flaring policies' implementation, the challenges and politics in managing the trade-offs between fossil-fuel-based economic development and low sustainable carbon and social development become even more stark. Economic diversification to avoid heavy dependency on oil and gas revenue and steering policy implementation in gas flaring management in a complex MLG structure provide a key pathway for progress. Greater clarity over the power structures operating across the federal system could support stronger policy coherence, which could, in turn, lead to more effective environmental policy implementation, regulation, and enforcement. There is also an urgent need for coordinated horizontal governance to involve a greater array of stakeholder voices, strengthening the various federal institutions to promote policy coherence to reduce the inconsistency across sectors revealed in our analysis. This requires stronger alignment between environmental and other sectoral policy goals, strengthening regional/state powers within the quasi-federal system, and avoiding 'rural sacrifice' for geographically remote regions from the dominant political centre. A collaborative policy framework mainstreamed across relevant sectors is crucial to mitigate sectoral policy goal conflicts while the Federal Government must mobilise the political will to stop gas flaring. Environmental justice and concerted action to reduce gas flaring may nevertheless be supported through a combination of international pressure, local capacity building and a persistent push for localisation and 'bottom-up' governance reforms.

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Chapter 4

Global gas flaring and energy justice: An empirical ethics analysis of stakeholder perspectives

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Abstract

Global gas flaring harms human and non-human health and well-being while contributing to climate change. Flaring activity in the global oil and gas sector is a significant matter of energy justice – concerning the distribution of risks, benefits and harms, recognition of rights, and decision-making influence within gas-flaring-affected communities. This mixed method empirical ethical analysis of gas flaring and energy justice combines Q-methodology and stakeholder interviews with representatives of 14 gas-flaring-affected countries (n=35) to evaluate the context-sensitivity of distributive, procedural, recognition, and cosmopolitan justice principles to gas-flaring governance. Four dominant normative perspectives emerge around this topic. These perspectives concern: a) government-led zero flaring policy; b) multi-scalar economic governance; c) business responsibility and social license; and d) localism and community empowerment. We find that: first, there is strong stakeholder support for zero-flaring globally. Second, coordinated multi-scalar governance from international-national-local regulatory authorities is desired to protect marginalised communities. Third, egalitarian rights-based approaches are prioritised over utilitarian approaches in planning for oil and gas extraction. Fourth, business responsibility necessitates transparent communication of flaring activities and impacts and the Polluter Pays Principle of environmental redress to affected communities. Finally, stakeholder disagreement centres upon the practical mechanisms to achieve just outcomes - including compensation, the role of local authorities, regulatory agencies, Environmental Impact Assessment, and efforts to tackle rent-seeking and corruption. We conclude that further stakeholder engagement is needed on the implementation processes for gas flaring elimination, rather than the goal itself, through carefully facilitated dialogue and negotiation.

Keywords: gas flaring, energy justice, environmental justice, Q-methodology, environmental discourses

4.1. Introduction

Gas availability in world markets has recently become an acute energy security issue, in part due to the re-opening of the global economy following the Covid-19 downturn and Russia's invasion of neighbouring Ukraine in February 2022. Growing pressure on natural gas resources and gas transmission flows exacerbates global concern over gas sustainability and the waste produced through flaring. Gas flaring is the disposal of excess natural gas by burning it in the open air. It occurs in chemical plants, natural gas processing plants, offshore and gas rigs, oil and gas extraction sites and petroleum refineries. Flaring occurs for several reasons, including a lack of market access or transport infrastructure for gas and the prohibitive costs associated with transporting gas from geographically remote regions. Other reasons include depressurising gas extraction equipment to manage unpredictable and large pressure variations by reducing explosion risks and legal ambiguity over how associated gas should be processed [1]–[4]. Collectively, these factors make gas flaring a common industrial practice in the oil and gas sector. However, it is increasingly recognised in policy and academic networks that flaring represents a waste of natural resources and creates a significant environmental burden locally and globally. Specifically, flaring bears a range of social, health and ecological risks and economic externalities in communities that host oil and gas extraction [4]. Associated adverse impacts of flaring activity include respiratory and cardiovascular health impacts from particulate matter, skin cancers and lesions via dermal exposure and the ingestion of contaminated water, which can alter the stomach pH and cause ulcers [5], [6]. The broader environmental health implications of flaring for climate change and localised air pollution from CH_4 and black carbon [7]–[13] affect air and water quality, ecosystem services, biodiversity, and crop production [14], [15] making this a significant issue of environmental and energy justice.

The seven countries with the highest shares of gas flaring currently produce 40% of annual global oil and gas and account for 65% of total global flaring [16], though reduced gas flaring may only have a short-term effect in reducing the carbon intensity of fossil-fuel energy generation, acting as a "bridge fuel" when substituting oil or coal [17]. As such, natural gas remains the preferred option amongst major electricity providers [18], [19]. Al-Hamed and Dincer [20] argue for natural gas use in rail transportation to ameliorate the environmental impacts and maximise the economic advantages of switching from diesel fuel. Consequently, as Gillessen et al. [21] note, numerous commentators have argued in favour of natural gas as a bridge or transition fuel to provide short-term environmental benefits over other fossil fuels whilst maintaining energy security and affordability benefits. Despite this, the carbon intensity of natural gas remains considerably higher than equivalent renewable alternatives.

Changing energy geopolitics, gas demand, and production are mediated by processes of global governance, including that concerning climate change mitigation. Notable among global governance measures are the Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC) [21], reinforced at COP 26 in 2021, and voluntary governance arrangements, including the partnership model espoused in the World Bank Global Gas Flaring Reduction Initiative [22]. Despite concerted global action to end gas flaring, many nations, particularly in the Global South, lack the capacity and political will to implement such changes. There is often a lack of viable markets for excess gas production, a lack of operational policies and regulatory commitments to gas flaring reduction, and a generally permissive attitude towards flaring as long as gas (and associated tax) revenues continue to flow [23]–[26]. However, it is important to note that gas waste through flaring is a significant economic development issue in its own right. The World Bank/GGFR data [27] estimated that 142 Bcm of natural gas flared in 2020 alone is sufficient to power sub-Saharan Africa. The top ten countries' diffusion of gas flaring shows relatively consistent flare volumes over 2016 -2020 (see Table A1). Reducing gas waste through flaring would be a 'quick win' for climate action and social development in the short term when implemented alongside other structural energy system decarbonisation measures.

International policy responses to global gas flaring activities also increasingly emphasise *just* sustainable transition actions, specifically in countries and communities dependent on domestic oil and gas production for economic and social development. The combination of gas flaring's local and global environmental and geopolitical impacts requires greater systems-level thinking about energy production, marketing and consumption, and infrastructure. It also requires a greater understanding of diverse stakeholder perspectives and stronger legal and regulatory mechanisms to ensure oil and gas sector compliance with flaring reduction measures. There is, therefore, an urgent need to research the prospective benefits, justice and inequality dimensions associated with flaring to inform the design of "good governance" mechanisms towards flaring practices within the industry. As such, we aim to provide an *empirical ethical* approach (described below) to assess and analyse stakeholder perspectives relating to principles of energy justice and challenges stemming from social-environmental harms associated with global gas flaring. In doing so, we provide important normative insight that could inform the design of future gas flaring policies.

4.2. Energy Justice in Global Gas Flaring

The governance of gas flaring is a matter of local and global energy justice. Conceptually, energy justice is a relatively new 'twin' discipline of the established field of environmental justice studies that applies ethical, political, and spatial analysis to the normative evaluation of energy systems. Energy justice evaluation commonly assesses the interrelated socio-technical dimensions of energy production and use. Energy justice analysis has been applied to policy frameworks, production, transmission and consumption systems, demand management, social movements and activism, security of energy supply, geopolitical relationships, market access, post-colonial social development, extractivism, and responses to global climate emergencies [29]. We posit that energy justice falls within the purview of *empirical ethics, by which scholars integrate moral theory and empirical data to reach a normative conclusion regarding* specific social practices [28]. Empirical ethics regarding energy justice and global gas flaring necessitate social science research into normative stakeholder perspectives on gas flaring justice principles, the impacts upon affected communities, and insight into policy actions across the different country contexts in which flaring occurs.

Though the *justice* framing of socio-technical system evaluation is diversely theorised across applied philosophy, geography and science and technology studies [29]–[31], a typical 'top-level' framing of energy justice reveals four categories of normative principles that we subject to empirical analysis:

1. *Distributive justice:* concerning spatial, governance, temporal and scalar patterning of benefits and burdens
2. *Procedural justice*: concerning due process, fair treatment of individuals and host communities, and opportunities for public participation in decision-making
3. *Recognition justice*: concerning how decision-making authorities value and respect the identities of vulnerable and marginalised groups, and how alternative voices, identities, and inclusive representation are managed within environmental governance processes; and
4. *Cosmopolitan justice*: concerning global externalities from associated greenhouse gas (GHG) emissions, pollution, and health impacts, and how these impact the human rights of affected peoples (Table 4.1).

Social science case study analyses of gas flaring have largely been place-based and predominantly in the USA [32]–[35] and Niger Delta [36]–[38]. These studies have revealed the importance of rights, fairness, well-being, and participation in governance in ensuring just decision-making outcomes for affected communities. Building from these, we take an expanded and abstracted approach to the empirical ethics analysis in this study to focus on justice and inequality issues that arise as decision-making authorities seek to improve gas resources efficiency or phase them out to meet energy transition goals. Inevitably, when questions of normative evaluation are expressed by diverse stakeholder representatives, competing judgements and differing underlying guiding principles will lead to different policy choices and outcomes. Understanding the patterns of consensus and disagreement surrounding the justice issues raised is thus an important component in developing fair and inclusive gas flaring policies that are sensitive to stakeholder values and concerns and thus ensure stakeholder 'buy-in' to proposed policy and environmental management solutions.

Our empirical ethical analysis aims to improve the context-sensitivity of energy justice principles [39] to gas flaring policy and practice by drawing upon diverse perspectives from stakeholders from 14 different gas-flaring-affected countries. We operationalise established energy justice principles as framing mechanisms to better understand the discourses of gas flaring governance from the global perspectives of gas flaring stakeholders. Of note is our innovative use of Q-methodology to establish the context-sensitivity and heterogeneity of discourses of energy justice principles surrounding gas flaring governance. Q-method is an exploratory method used to define emergent perspectives around a topic of interest. It neither tests its participants nor imposes a priori meanings, thus is unsuited to hypothesis testing. As such, our research question to which the Q-method is applied is: What are the emergent perspectives on energy justice and global gas flaring governance, and how can consensus and conflict between competing perspectives help to inform fair and inclusive gas flaring policies?

Table 4.1. A conceptualisation of energy justice components and applications to gas flaring.

	Definition and Application
Distributive Justice	Distributive justice concerns the spatial/scalar sharing of goods (e.g., natural gas resources) and "bads" (environmental harms and health risks from gas flaring) or equitable or effective distribution of social and economic benefits and burdens from natural gas resources across communities or generations. ***Gas flaring-specific concerns:*** Benefits and burdens sharing of natural gas exploration, extraction and use, equity of access to green space, compensation to host communities, equal availability of energy (electricity), access to clean air and water, spatial patterning of gas flaring pollution risks, exposure to natural disasters and climate change impacts.
Procedural Justice	Procedural justice concerns decision-making, principally who is involved and has influence in decisions, access to information about environmental risks and burdens, involvement in policy design and redress through the policy-making process, and adherence to due process and fair treatment of individuals/groups under the law. ***Gas flaring-specific concerns:*** Planning processes, regulatory practices, environmental rights, due process, public participation, deliberative mechanisms of decision-making.
Recognition Justice	Recognition justice concerns who is accorded respect and how individual and community identities, social values and cultural practices are respected and valued. Inclusion of diverse, vulnerable, marginalised, poor, or under-represented or misrepresented peoples and demographic groups in a society. ***Gas flaring-specific concerns:*** Impacts of gas flaring on vulnerable groups, particularly minorities, people of colour, or indigenous people within gas flaring host communities, use of appropriate language in environmental communication, respect for mechanisms of self-governance and community identity.
Cosmopolitan Justice	Cosmopolitan justice concerns universal respect for individual human rights irrespective of protected characteristics or cultural identity. Alternatively, it concerns the global scope of justice demanding adherence to general principles, including respect for civil and democratic rights and substantial socio-economic egalitarianism. ***Gas flaring-specific concerns:*** Negative market externalities that are produced or distributed globally. For example, releasing toxic pollutants such as sulphur dioxide and NOx can lead to acid rain, low-level ozone, and smog formation. GHG emissions (including CO_2) contribute to climate change.

Source: Adapted from [40]–[43].

4.3. Methodology

Q-method is a mixed-method social research approach that combines factor analysis with qualitative interpretation to elicit factors that correlate to scores assigned to a set of pre-defined statements [44]–[46]. Q-method provides elements of structured statistical and interpretive qualitative analysis [47], [48] useful for exploring respondents' subjective attitudinal perspectives and establishing conventional viewpoints around a controversial topic. As such, it has grown in popularity in recent years in environmental governance research [49]–[52] and has been used to delineate stakeholder perspectives concerning controversial environmental debates [44] and explore complex stakeholder value dimensions within such debates [49]. We employ it here as a methodological innovation in *empirical ethics* [50] – a means through which individual stakeholders can reflect upon the energy justice dimensions of gas flaring operations and provide statistical rigour in an evaluation of the patterning of moral judgements made by such stakeholders throughout the Q-sorting and exit interview process.

Methodologically, we follow established protocols for Q-method study detailed in [51], [52], deriving six primary steps for Q-method analysis:

(1) Develop the concourse
(2) Develop the Q-set
(3) Recruit the P-set
(4) Q-sorting of statements
(5) Exit interview
(6) Statistical and interpretive data analysis [53].

Each of these is discussed below.

1) Develop the concourse. The "concourse" refers to a broad collection of statements, termed Q-items, that encapsulates the nature of the public discourse on the topic under investigation. We drew 55 initial Q-items from preliminary interviews, consultations and expert surveys, and qualitative interview data (see [54]). Interviews were conducted with 7 specialists (4 representatives from environmental NGOs, advocacy groups, and 3 environmental campaigners living in gas flaring host communities). Interviews were carried out via zoom/telephone and transcribed. The expert survey was conducted via email. Data from the interviews were analysed using NVivo12 software. The expert survey targeted participants with a PhD in oil and gas and related fields and policy experts. 59 experts were contacted through e-mail, and 23 completed and returned surveys.

Q-items drawn from primary interviews were combined with statements drawn from secondary data extracted from published articles related to gas flaring and environmental/energy justice literature, as shown in Table A2. Articles were obtained through an internet search and selected by combining search terms with the subject heading "gas flaring and environmental/energy justice" (Table A3). 393 relevant articles were analysed and selected from gas flaring and environmental/energy justice literature.

2) Develop the Q-set. The draft concourse drawn from primary and secondary qualitative data was analysed thematically using NVivo12 software. Thematic analysis was used to pre-structure the energy justice components presented in Table 1, leading to the characterisation of the concourse and selected Q-statements in Table 2 and the final presentation provided in Table 3. This structure was not revealed to the respondents but was exclusively intended for the researchers. Draft statements were modified from their original sources to reflect the study's aim and objectives while retaining a balance of anti-gas flaring, pro-flaring, and neutral perspectives. The initial draft of 55 statements was piloted with 3 experts and researchers and then redrafted into a smaller 36-statement Q-set for manageability, e.g., [55], [56] before being further checked independently by 2 academics and industry experts. The final version was administered online using Q-method software (https://qmethodsoftware.com). All the Q-sort rankings were conducted between February and March 2022.

3) Recruit the P-set. The P-set in a Q-method study represents the observations, while the Q-set represents the variables [57]. The P-set (where P means "people") is selected to represent a wide diversity of viewpoints among informed and interested stakeholders, much in the same manner as a qualitative interview study (see Table 4 for a list of participants and their roles). For this study, the P-set was selected based on participants' knowledge, interest, and participation in the public debate concerning gas flaring, environmental/energy justice, climate change, transition, and other environmental issues. They included those with professional backgrounds in oil and gas, alongside those with a PhD in oil and gas and related fields, academics, law and governance, health and safety, journalism, software and computer engineering, citizen stakeholders living in gas flaring host communities, environmental advisors/consultants, and company directors. Participant input was requested through LinkedIn, email, and phone contacts. 100 were contacted through a purposive-snowball sampling approach, while stakeholders who agreed to participate and those that declined were also asked to refer other suitable participants from within their professional and individual networks. A final P-set of 35 produced the usable Q-sorts (response rate =35%, average time of completion 28 minutes), from which 34 responded to the exit interview. While 8 out of the 100 P-set were incomplete and unusable data, 57 declined to participate due to personal choices. As is standard in Q-method studies, the P-set sample size need not be large [46]. However, as shown in Table 4.4, the P-set represents heterogeneous perspectives across diverse stakeholder representation (both in terms of geographic spread and sectoral background), which is generally preferable to proportionality [45].

4) Q-sorting of statements. Q-sorting is the process by which each respondent evaluates the Q-sort by assigning a score to each opinion statement to show the extent of agreement and disagreement, leading to a matrix of cross-correlations between all Q-sorts [46]. In a manner similar to [58], [59], we conducted expert interviews with Q-sort participants to validate and contextualise the statement sorting process and to provide additional rich descriptions necessary for the qualitative interpretation of the emergent perspectives. To acquaint participants with the online Q method software and the 36 statements, participants were forwarded a tutorial video to watch the process of completing the Q-Sort before beginning the Q-Sort, offering a two-step sorting process. Participants were then instructed to read the 36 statements carefully and then place the individual items into a grid format from -5 (least like my perspective) to +5 (most like my perspective) with a quasi-normal distribution pattern (see Figure 4.1). The sorting grid is shaped symmetrically around 0, as shown below:

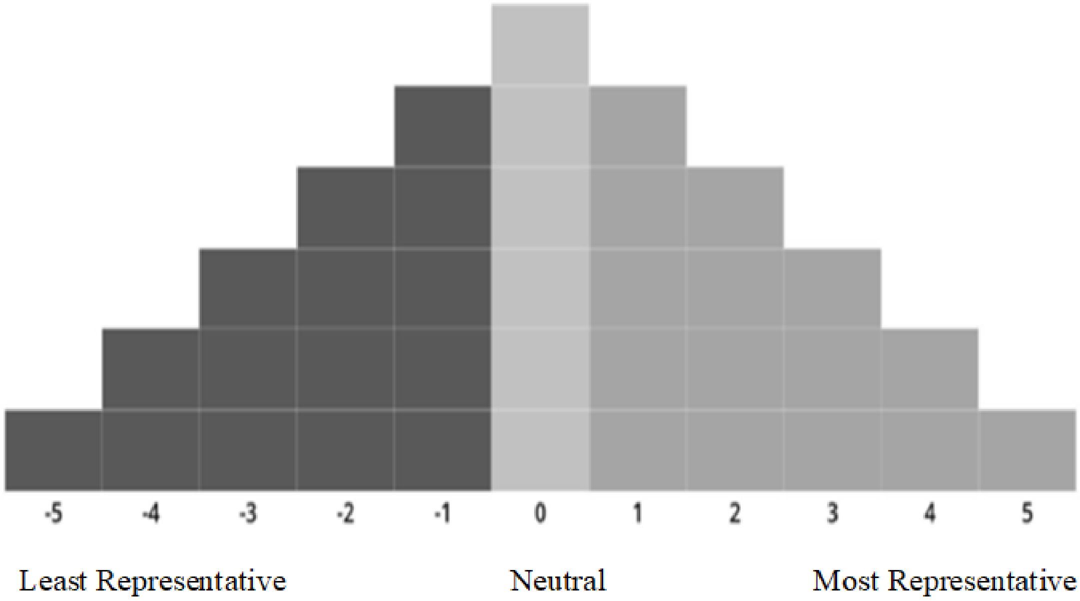

Figure 4.1. Quasi-normal distribution of the final sort.

5) Exit interview. Respondents were asked to reflect upon their statement placement in the grid to provide further qualitative validity to constructing perspectives in the analysis stage. Note that 1 respondent out of 35 P-set that produced the usable Q-sorts participated in the survey but declined to respond to the exit interview questions.

6) Analysis. Q-method software (https://qmethodsoftware.com) was used for the data analysis. Q-method analysis generates factors: a weighted average of Q-sorts representing an archetypical shared perspective of respondents [60]. Respondents who share similar views are extracted to define individual factors. The factors and the associated ranking of statements show a typical way a respondent with a similar perspective would rank a statement. In terms of statistical analysis, first, Pearson correlation was applied to extract a correlation matrix between all the Q-sorts. Second, Principal Component Analysis (PCA) was used for factor extraction, which, unlike Centroid Analysis, in PCA, the number of factors was automatically chosen and reflected in the "extracted factors" as unrotated factor loadings of all Q-sorts (see Table A4). Third, factors with Eigenvalues >1.00 are considered statistically significant. Based on an evaluation of the number of participants loading on all factors, distinguishing statements, Eigenvalues, and assessment of the scree plot, four factors were selected and subjected to orthogonal (Varimax) rotation (see Fig. A1). The exit interview data were analysed thematically using NVivo12 software, and this fed into the qualitative interpretation of the emergent perspectives.

4.4. Results and Perspectives Interpretation

Four dominant perspectives on energy justice and global gas flaring emerged (Tables 4.3 and 4.4), accounting for 58% of the cumulative variance. Factor arrays explaining >50% of cumulative variance are favoured in Q-method studies [61]. References to important Q-statements, e.g., S20, are included in the various descriptions as the narratives are constructed from the Q-statements.

Although there is no conventional number of factors to retain and utilise [52], there are two most widely used methods to determine the number of factors to extract:

1. The number with Eigenvalues > 1.00
2. Factors with at least two significant loadings [45], pp. 222–223).

For this research, all eight unrotated factors (see Table A4 and Fig. A1) met the above conditions, as suggested by [45]. As the Q study relies on the researcher's familiarity with the subject to make the judgement and their skills, we rotated and retained the first four Eigenvalues, which explain 58% of the variance.

Table 4.2. Characterisation of the concourse and selected Q-statement.

Overarching theme	**Issue (Q-set statement number)**
Distributive Justice	• Communities affected by gas flaring should be compensated with subsidised electricity S3. • Gas flaring is a separate issue from energy poverty, and the two should not be confused S4. • The benefits and burdens of gas flaring should be shared fairly between rich and poor communities S5. • Governments should subsidise oil and gas production S6. • Current environmental protections from oil and gas flaring sufficiently balance ecological costs and economic benefits S7. • A thriving oil and gas sector is essential for the economic vitality of rural gas flaring host communities S10. • Action taken on rent-seeking and corruption should be the first step in tackling gas flaring S12. • Gas flaring is a problem when the industry is dominated by international capital, and oil and gas companies extract the value of the gas to another country S16. • Oil and gas companies should voluntarily adopt the Polluter Pays Principle: offering compensation and funding for environmental remediation S30.

Procedural Justice	• To tackle gas flaring, we should improve transparency and industry accountability in the global oil and gas sector S1. • The environmental impacts of oil and gas flaring are experienced locally and should therefore be managed by local authorities S11. • Voluntary disclosure of gas flaring emissions by oil and gas companies is desirable S13. • All data on gas flaring emissions, health impacts, and distribution patterns should be made publicly available S17. • Greater levels of public money should be spent regulating and enforcing gas flaring control measures S18. • Host communities' concerns about gas flaring impacts should be integrated into governments' oil and gas exploration and development decisions S20. • Governments should set up an independent community watchdog group and an advisory group of community leaders to examine, monitor and review government regulatory agencies and the activities of international oil companies S21. • Oil and gas companies should be mandated to complete a full Environmental Impact Assessment (EIA)for any activities where gas flaring will occur S24. • Governments should lead decisions on oil and gas flaring in the national interest S25. • State and local government agencies and officials with public input should lead gas flaring decisions S22. • Local communities should have the power to stop oil and gas extraction in their local communities if they do not want it to happen S23. • A national regulatory agency should make decisions on managing gas flaring environmental impacts S26. • More should be done to highlight the problem of gas flaring to raise awareness and build collective action for regulation changes S33. • Global gas flaring produces avoidable emissions, and legislation should stop such practices S35.
Recognition Justice	• Oil and gas companies should build long-term community trust in the locations where they extract natural resources S19.

	• Host communities' concerns about gas flaring impacts should be integrated into governments' oil and gas exploration and development decisions S20. • Governments need to protect communities from feeling dispossessed of their land and livelihoods S28.
Cosmopolitan Justice	• It is acceptable for gas flaring to take place in areas of low population density S27. • Heavy gas flaring nations should compensate neighbouring countries for environmental impacts caused by transboundary pollution S29. • Governments should accept responsibility for gas flaring impacts, even if privately owned industries cause them S31. • All countries across the world should aim for zero gas flaring S34.
Support/Non-Support for gas flaring	• We should reduce the amount of waste gas in order to improve profitability in extraction S2. • Current environmental protections from oil and gas flaring sufficiently balance ecological costs and economic benefits S7. • Energy generation using natural gas is positive for the environment S8. • Revenue generation from oil and gas production outweighs the environmental cost S9. • A thriving oil and gas sector is essential for the economic vitality of rural gas flaring host communities S10. • Gas flaring is simply a routine practice in the oil and gas industry S14. • The dangers of gas flaring are exaggerated S15. • The health and environmental impacts on oil and gas flaring communities are shameful S32. • Gas flaring should be allowed as it improves safety for oil and gas workers by reducing the risk of explosion in pipelines and other infrastructure S36.

Table 4.3. Factor loadings of Q-statements.

No Statement	Factors			
	1	2	3	4
1. To tackle gas flaring, we should improve transparency and industry accountability in the global oil and gas sector.	0	+2	+5	+5
2. We should reduce the amount of waste gas in order to improve profitability in extraction.	-1	+3	+2	+1
3. Communities affected by gas flaring should be compensated with subsidised electricity.	-1	+3	-4	+4
4. Gas flaring is a separate issue from energy poverty, and the two should not be confused.	-1	0	-1	0
5. The benefits and burdens of gas flaring should be shared fairly between rich and poor communities.	-2	+2	-2	+3
6. Governments should subsidise oil and gas production.	-3	0	-3	-2
7. Current environmental protections from oil and gas flaring sufficiently balance ecological costs and economic benefits.	-3	+1	-1	-4
8. Energy generation using natural gas is positive for the environment.	-2	+2	+2	-2
9. Revenue generation from oil and gas production outweighs the environmental cost.	-3	0	-5	-5
10. A thriving oil and gas sector is essential for the economic vitality of rural gas flaring host communities.	-1	-4	0	-3
11. The environmental impacts of oil and gas flaring are experienced locally and should therefore be managed by local authorities.	-2	-1	-4	-1
12. Action taken on rent-seeking and corruption should be the first step in tackling gas flaring.	-2	-3	+1	-1
13. Voluntary disclosure of gas flaring emissions by oil and gas companies is desirable.	0	+1	+1	+1
14. Gas flaring is simply a routine practice in the oil and gas industry.	-4	0	-2	0
15. The dangers of gas flaring are exaggerated.	-5	+1	-2	-4
16. Gas flaring is a problem when the industry is dominated by international capital, and oil and gas companies extract the value of the gas to another country.	0	-1	-1	-2
17. All data on gas flaring emissions, health impacts and distribution patterns should be made publicly available.	+1	0	+3	+1
18. Greater levels of public money should be spent regulating and enforcing gas flaring control measures.	0	+1	-3	0
19. Oil and gas companies should build long-term community trust in the locations where they extract natural resources.	+2	0	+4	+3
20. Host communities' concerns about gas flaring impacts should be integrated into governments' oil and gas exploration and development decisions.	+1	+1	+2	+2
21. Governments should set up an independent community watchdog group and an advisory group of community leaders to examine, monitor and review government regulatory agencies and the activities of international oil companies.	+1	-3	+1	+2

22. State and local government agencies and officials with public input should lead gas-flaring decisions.	0	-1	0	-1
23. Local communities should have the power to stop oil and gas extraction in their local communities if they do not want it to happen.	0	-2	-2	+3
24. Oil and gas companies should be mandated to complete a full Environmental Impact Assessment (EIA) for any activities where gas flaring will occur.	+2	-3	+3	+4
25. Governments should lead decisions on oil and gas flaring in the national interest.	+1	-2	+3	-1
26. A national regulatory agency should make decisions on managing gas flaring environmental impacts.	+2	+3	0	-1
27. It is acceptable for gas flaring to take place in areas of low population density.	-4	-1	-1	-2
28. Governments need to protect communities from feeling dispossessed of their land and livelihoods.	+3	-2	+2	+2
29. Heavy gas flaring nations should compensate neighbouring countries for environmental impacts caused by transboundary pollution.	+1	-1	+1	0
30. Oil and gas companies should voluntarily adopt the Polluter Pays Principle: offering compensation and funding for environmental remediation.	+2	+2	+4	+1
31. Governments should accept responsibility for gas flaring impacts, even if privately owned industries cause them.	+3	-2	-1	+1
32. The health and environmental impacts on oil and gas flaring communities are shameful.	+3	-4	-3	+2
33. More should be done to highlight the problem of gas flaring to raise awareness and build collective action for regulation changes.	+4	+4	0	0
34. All countries across the world should aim for zero gas flaring.	+5	+4	0	0
35. Global gas flaring produces avoidable emissions, and legislation should stop such practices.	+4	+5	+1	-3
36. Gas flaring should be allowed as it improves safety for oil and gas workers by reducing the risk of explosion in pipelines and other infrastructure.	-1	-5	0	-3

Table 4.4. Participant details and factor loadings for each Q-sort.

Participant-Country of Origin/Domicile	Factor 1	Factor 2	Factor 3	Factor 4
Academics/Industry experts				
1. Academics/Citizen stakeholder (HOD Science/Physics)- **Qatar/UK/Nigeria**	**0.72335***	-0.08772	0.08478	-0.0781
2. Academics (Lecturer & Environmental Consultant)-**Nigeria**	**0.67589 ***	-0.15055	0.02629	0.08007
3. Academics (Associate Professor)- **Norway**	**0.44256***	-0.26774	0.19206	0.24521
4. Academics (Lecturer/Consultant Geologist)-**Nigeria**	0.13318	0.32201	**0.62467***	0.27804
Industry Stakeholders/ Scientific				
5. Oil & Gas industry (Head of Offshore HSE)-**France**	**0.6819***	0.33425	-0.05702	0.22109
6. Oil & Gas industry (Senior Operations Supervisor)**-Nigeria**	**0.68824***	0.09426	0.39133	0.0095
7. Oil & Gas industry (Engineer and Researcher)- **Netherlands**	**0.52339***	-0.07727	0.27149	-0.02693
8. Subsurface Consultancy (Chief Production Technologist)-**Netherlands**	**0.73184***	0.02908	0.40174	-0.113
9. Oil & Gas industry- Petrojet, Cairo) (Senior Process Engr)-**Egypt**	**0.65488***	0.17031	0.47785	0.24522
10. Oil & Gas industry (Deputy General Manager) also from gas flaring host community (**France/UK/Nigeria/Angola)**	-0.18743	**0.73774***	0.2152	0.34751
11. Oil & Gas industry (Environmental Consultant BTGap, L.L.C.)-**USA**	0.19564	0.01051	**0.71622***	0.03153
12. Oil & Gas industry (HSE Manager)-**France/Nigeria**	0.09295	-0.07199	**0.35172***	0.13729
13. Oil & Gas industry Technical Advisor-**USA/Nigeria**	-0.03891	0.36997	**0.51386***	0.12232
14. Mexican Energy Consultancy (Natural Gas Analyst)-**Mexico**	**0.66676***	0.07393	0.55255	0.34319
Directors, regulatory, governmental, and NGO stakeholders				
15. Environmental-Ecosystem Pipeline (Regional Manager)-**UK**	**0.69507***	0.27266	0.19908	0.30453
16. Statistics Canada (Environmental Specialist)-**Canada**	**0.83497***	-0.16198	0.22799	-0.1806
17. Energy & Environmental Management (CEO& President)-**USA**	0.17984	**0.74062***	0.0689	-0.1641
18. Energy & Environmental Management (Senior Energy Resource and Regulatory Advisor)**-Canada**	0.01932	-0.24368	**0.72961***	0.03632
19. Sustainability & Environmental Management (Environmental. Advisor)-**UK**	0.10111	-0.01047	0.1084	**0.81027***

20. Environmental Defense Fund (Senior Director, Regulatory & Legislative Affairs)-**USA**	**0.78046***	0.1472	-0.03698	0.24198
21. African Development Bank (Director)- **Côte d'Ivoire**	**0.68517***	0.45602	0.08175	0.22511
22. Regulatory/NGO (Senior Policy Campaigner/Analyst)-**USA**	**0.77995***	0.09321	0.00011	0.3345
23. Law & Governance/Public (Policy Legal Consultant) -**Nigeria**	**0.67046***	0.28055	0.27826	0.42597
24. Law and Governance (Principal Legal Consultant)	0.2107	0.09568	**0.50459***	-0.01311
25. Renewable Energy (Legal Consultant/Policy Analyst) -**Nigeria**	0.32222	-0.1365	0.12792	**0.73029***
26. NGO (Entrepreneur and an Engineer)-**Nigeria**	**0.65989***	0.0963	0.28754	0.1175
Citizen stakeholders				
27. Citizen stakeholder (Software Engineer)-**USA/Nigeria**	**0.83426***	0.14896	0.04936	0.3245
28. Citizen stakeholder (Rector)-**Nigeria**	**0.43899***	-0.18241	0.34802	0.06814
Others				
29. Journalism and Media (Journalist)-**UK/Iran**	0.16135	0.13938	0.06422	**0.7655***
30. Unknown	**0.5571***	0.33652	0.07411	0.40713
31. Unknown	0.06581	**0.74441***	-0.1063	-0.19574
Unflagged				
32. Academics (Professor)-Environmental Science from gas flaring state in the **Niger Delta**	0.41417	0.28597	0.40323	0.45962
33. Researcher-**Canada**	-0.0092	-0.11997	0.07274	0.27188
34. Director at Carbon Counts-**Germany**	0.42579	-0.22814	0.28691	0.22932
35. Academics- Senior Lecturer-**Nigeria**	0.32347	0.28682	0.47529	0.35254
Eigenvalues	12.66465	2.98467	2.49626	2.14835
% Exp Var.	36	9	7	6
Cumulative % Exp. Var.	36	45	52	58
No. of loadings	19	3	6	3

N.B. Z-score numbers marked in ***bold*** represent defining sorts for that factor (p< 0.05).

As both the statement value and *z* scores indicate the ranking of statements in each factor, the factor's composite Q-sort and difference scores reveal the salient statements requiring specific attention when describing and interpreting the various factors [48], [62], [63]. To establish the boundaries of emergent perspectives, we followed established research practices in environmental governance research [64]–[66] analysing:

1. Statement values beginning with the highest scores (+5) and lowest (-5) scores for each factor, working "inwards" towards zero.
2. The significance of each statement's z-score (the top positive z-scores and bottom negative z-scores)
3. Explanations and context drawn from the exit interview.

Interpreting the four distinctive composite Q-sorts with elaborations by respondents enabled us to identify four perspectives, labelled A-D, each given a descriptive moniker to summarise its key features.

A. **Government-led zero-flaring policy**
B. **Multi-scalar economic governance**
C. **Business responsibility and social license to operate**
D. **Localism and community empowerment**

As is common with Q-method studies, we make no claims for generalisability to broader populations within the statistical analysis. Instead, the four perspectives explain the likely patterns of responses that might emerge within and between diverse stakeholder groups. Notably, there is considerable diversity in perspective shown across the nominally identified stakeholder categories shown in Table 4.4. Perspective A is correlated with all industry stakeholders, citizen-stakeholders from gas flaring host communities, academics, and people with a higher education and training in environment and related fields (n=19). Perspective B is highly correlated with industry stakeholders and one non-affiliated citizen stakeholder living in a gas flaring host community (n=3). Perspective C is correlated with regulatory and technical advisors, legal and environmental consultants, and ordinary citizens (n=6). Perspective D is correlated with one citizen-stakeholder from a gas flaring host community, legal/renewable energy, and environmental consultants (n=3). Given the number of stakeholders loading on Perspective A and the clear drop between factors 1 and 2 on the scree plot (Fig. A1), we infer the clear dominance of Perspective A amongst our respondents and potentially among a broader network of stakeholder voices. References to the characterisation of the concourse and selected Q-statements are included in Table 4.2.

4.4.1. Government-led Zero Flaring (Perspective A)

Perspective A is characterised by support for a government-driven ban on gas flaring, grounded in cosmopolitan, procedural, and distributive justice considerations. The stance on ending gas flaring is unequivocal. As respondent 24 stated in the exit interview:

> *"The issues that stood out for me are those that try to elucidate action by the government, oil prospecting companies and regulatory bodies on mitigating global gas flaring to a zero level".*

The defining statements S34, S33, and S35*[1] for this perspective were positively loaded, and statements S15*, S14 and S27 were negatively loaded. The defining aim for global zero gas flaring S34 is driven by the desire for greater outreach and awareness-raising of the core social and environmental impacts of flaring. This perspective is framed around building a coalition of interest and collective action towards regulatory change S33 and legislative practices to actively halt emissions S35*. There is a strong sense of the scale of negative gas flaring impacts and a belief that such impacts are not being exaggerated or distorted through public perception S15*. Rather, the impacts are construed as shameful S32*, and hence should no longer be routine practice in the oil and gas industry S14. Notably, within this perspective, the role of government is clearly emphasised. There is little support for a 'good governance' model of responsible flaring activity S1, nor providing local community involvement in decision-making S23 or compensatory benefits S3*. Instead, advocates of perspective A support a top-down ban or moratorium on flaring, thus removing the need for local-scale community procedural justice mechanisms.

We find that the justification for the zero-flaring stance is grounded in *egalitarian* conceptions of cosmopolitan justice. Proponents of this perspective are not persuaded by business-as-usual justifications, such as siting flaring activities in areas of low population density S27 to protect worker safety S36 or to reduce waste gas and improve profitability in extraction S2*. Across the statement sorting and exit interviews, this perspective is characterised by strong support for

[1] distinguishing statements (highlighted with * in the descriptions)

a ban on flaring. It also emphasises that all other ameliorative mechanisms, such as decision-making or compensation to the host communities that might alleviate energy injustice from flaring, are unnecessary or undesirable. Thus, according to this perspective, the only solution is a zero-flaring policy platform.

4.4.2. Multi-scalar Economic Governance (Perspective B)

Perspective B is characterised by the desire for multi-scalar governance and economic redress to gas flaring injustice. There is a strong desire for a global zero-flaring policy S34, which should be achieved through global governance mechanisms S35*, such as international treaties and government monitoring of progress towards net zero-flaring. There is a strong commitment by proponents of this perspective towards gas flaring governance at global and national levels, primarily through technocratic means S26*, i.e., greater reliance upon environmental management expertise to achieve just outcomes for communities. There was a rejection of broadly normative evaluations of flaring. For example, there was little support for the idea that gas flaring is a shameful practice S32*, despite a general lack of support for flaring overall as a routine practice S36. As respondent 2 described:

> *"The oil and gas business is necessary for the economic growth of the world. It can, however, be done more responsibly. The industrialised western world is driving the climate agenda while the developing countries in Africa and Asia need the oil and gas to grow and become fully industrialised".*

At local and regional scales, the picture is more complicated. There is strong support for compensation to communities through, for example, subsidised electricity as a distributive redress to environmental injustice S3*. This is partly because oil and gas are not seen as economically beneficial to the communities that support it as shown in S10, and proponents of this perspective remain equivocal about broader government subsidies of the oil and gas industry S6. As respondent 17 described in the exit interview:

> *"My involvement with gas flaring issues is driven by reducing the impact of the flaring around the host community and their benefits. The kind of issue that stood out for me is the impact of gas flaring on the host community that destroys the economy and reduces the impact of the flaring around the host community and their benefits".*

Though there is support for economic compensation and other distributive benefits, there is less support for strong procedural justice mechanisms at the local scale. For example, there was little support for providing communities with effective veto powers of the oil and gas development S23, nor for providing community decision-making control powers through EIA S24*, or watchdog powers to oversee government-led implementation of gas flaring governance mechanisms S21*. There is, in essence, a rejection of place-based politicisation of gas flaring impacts on the local host communities. Hence, there was no support for government intervention in protecting communities from disruption to place attachment and place identity resulting from environmental harm (such that local host communities feel dispossessed of their land and livelihoods) S28*. This perspective can therefore be characterised as supporting economic redistributive and 'top-down' regulatory redress to prevent environmental injustices from flaring, though without community-level procedural/participatory decision-making control.

4.4.3. Business Responsibility and Social Licence to Operate (Perspective C)

Perspective C is characterised by industry and government-led solutions to energy justice in the oil and gas sector, emphasising the issue of trust S19 - often termed a *social licence to operate* – through building business credibility and community relationships during routine oil and gas operations. The desire for proponents of perspective C for a full EIA for any activities where gas flaring would occur S24 reveals a need for regulatory and participatory input to governing gas flaring operations, given a lack of trust in industry activities**.** As respondent 20 indicated in the exit interview:

> *"The main issues that stood out are the environmental challenges faced by the local communities. For example, the Niger Delta region in Nigeria is experiencing significant environmental pollution, and the Federal or State Government is not doing enough to tackle the issues. In addition, the oil companies are not considering the impacts of their actions on people and the community".*

Within this perspective, gas flaring is defined primarily as an issue of good governance rather than gas flaring elimination. The perspective specifically formulates flaring as an issue of industry transparency as per S1, and the role of data availability on gas flaring and flaring impacts to public audiences in S17, alongside broader action to reduce corruption and rent-seeking amongst government authorities and industries in S12*. As respondent 28 stated:

"Oil and gas is the mainstream of funds in Alberta. Albertans want exploration but not in their backyard. I have been involved in many hearings where flaring was the main concern. Some concerns were due to being uninformed, and others led to good changes".

Therefore, transparency, clear communication, and accountability are key aspects of this discursive framing of flaring.

Other concerns in perspective C relate to the role of state and private finance in governing and regulating the oil and gas industry. There is strong support for the Polluter Pays Principle (S30) – that private finance from oil and gas revenue should support the environmental amelioration of flaring S18. Also, there is strong support for governments to lead decisions on oil and gas flaring in the broader national interest S25*. On the contrary, there is opposition to reducing flaring using state finances as shown in S18, and in providing economic redress to affected communities through financial compensation or benefits in kind S3*.

As an energy justice issue, proponents of perspective C present natural gas as providing environmental benefits as a lower carbon fossil fuel than, for example, coal (S8*), with gas seen as a so-called bridge fuel. However, environmental justice must involve regulatory and planning measures that ensure environmental protection at local scales – primarily through support for processes of EIA S24*, rather than local authority S11, or local community decision-making control S23.

To summarise, proponents of perspective C tend to favour market-based and business-led solutions to oil and gas flaring, primarily focusing on the governance arrangements for businesses to ensure accountability, transparency and community-relationship building to ensure good practice within the industry.

4.4.4. Localism and Community Empowerment (Perspective D)

Perspective D is characterised by the role of community control in environmental decision-making and the procedural dimensions of justice in gas flaring governance. Of particular interest is the role of community power in deciding on gas developments within the areas in which they live S23. As respondent 14 stated in the exit interview:

"Communities should have more power regarding decision-making, and companies and governments should be more transparent to ensure that communities are informed to make decisions. Activities that adversely affect the environment should be limited

through legislation, taxation etc., regardless of the perceived economic benefit of these activities".

Community empowerment also has economic redistribution dimensions, as proponents argue that the revenue from gas production insufficiently compensates for the environmental costs associated with flaring. There is a concern that the costs and benefits of oil and gas production are unevenly distributed and must be re-balanced S7*, to ensure fairness to local communities S5*. Redistributive mechanisms, such as subsidised electricity (or other forms of benefit in kind), are favoured as a compensation mechanism for hosting gas flaring operations as shown in S3*. In one exit interview, respondent 7 noted:

"The main issues that stood out were balancing the environmental and health cost of flaring and the financial benefits to host communities".

Perspective D is therefore defined through localism and community empowerment mechanisms to ensure environmental justice for gas-flaring-affected communities through EIA S24*, and economic redistribution mechanisms to ensure fair distributive justice to those negatively impacted by adverse health and environmental effects.

4.5. Discussion

The four dominant perspectives collectively account for 58% of the variation in perspectives on global gas flaring and energy justice issues. Each represents different aggregate views on gas flaring and energy justice, revealing potential agreement and disagreement held within and between stakeholder groups. Understanding these dynamics is useful to inform future stakeholder engagement and further empirical ethics study of energy justice and gas flaring governance. It reveals likely areas for consensus building ("quick wins" where conflict is less likely to occur) and likely areas of disagreement that would require careful facilitation of dialogue among competing perspectives. These are discussed in the following section.

4.5.1. Areas of Agreement

The correlation between factors reveals "consensus statements", where the various perspectives indicate tentative agreement. For instance, where factors 1 and 2 agree, but factors 3 and 4 disagree, there are benefits in exploring the source of the belief systems around that issue [67]. We use the terms "agreement/consensus" and "disagreement/dissensus" in our assessment of the variance across factor z-scores for each statement. Eleven ($n=11$) out of the 36 statements were identified as 'consensus statements' based on z-scores. However, five key areas of consensus were on S11, S20, S27, S30, and S16, relating to all perspectives cutting across the four identified tenets of justice.

All four perspectives agree that local authorities should not be the managing authorities for gas flaring reduction in S11 (procedural justice). Yet, they agree that gas flaring management must incorporate regulatory and planning measures that guarantee environmental protection at local levels while integrating host community concerns into national oil and gas decision-making as per S20 (procedural/recognition justice). More specifically, agreed normative perspectives on procedural justice emphasise work to improve institutional processes that create inequities [29], [68] and ensure due process, representative public participation, and process-oriented and deliberative democratic solutions to environmental governance of gas flaring [69]–[71]. Recognition justice is essential to ensuring just procedural outcomes for marginalised communities [72] on S20 across all perspectives is illustrative of a desire to link local, national, and global scales of energy justice – 'scaling up' local community concerns to national and supra-national policy authorities [73].

Notable is a rejection of utilitarian 'sacrifice zone' governance solutions [74]. All perspectives agreed that population density should not be a factor in the acceptability of flaring, notwithstanding geographical location S27. This is representative of broad acceptance of an egalitarian, rights-based normative position that all people have a right to a clean and safe environment [75]–[79].

Distributive justice concerns that the costs and benefits of oil and gas production needed to be re-balanced S7* were expressed by consensus on the Polluter Pays Principle as a starting point for distributive justice S30. This mirrors empirical findings of uneven benefit/risk distribution in research into gas flaring practices [33], [80]–[83]. Distributive justice is also defined in relation to the challenge of global *extractivism* and *enclaving* [84]–[86] defined in S16. Perspective A was neutral, and perspectives B, C and D disagreed that gas resources were solely extracted to benefit another country's economy S16. Concerns over distributive injustice and vulnerability, especially through job losses in local host communities where oil and gas enclave development is prevalent, were highlighted in the exit interviews. It is noteworthy that concession agreements still give IOCs the right to operate within an oil and gas enclave, a social and economic consequence of global fossil fuel supply chains [85]. Gas flaring within enclave economies alters the structure of host communities' job opportunities – IOCs often export labour in the form of expatriates to the enclave regions, exacerbating rent-seeking and corruption, e.g., S12, and altering the regulatory structure in countries with a unitary system or low regulatory compliance [84], [87]. The relationship between host community benefits through job creation and the extractive nature of capital resource flows through enclaves of migrant labour illustrated a broader distributive global justice concern within oil and gas supply chains, and this is a key concern for the stakeholders in this study.

Six other statements that do not distinguish between factors are crucial as they form a common basis for building a future gas flaring governance approach [88] (Table 4.5).

Table 4.5: Q-sort statements that do not distinguish between factors extracted from table 4.3.

Statement	Statement No.
Governments should subsidise oil and gas production.	S6
Voluntary disclosure of gas flaring emissions by oil and gas companies is desirable.	S13
All data on gas flaring emissions, health impacts, and distribution patterns should be made publicly available.	S17
To tackle gas flaring, we should improve transparency and industry accountability in the global oil and gas sector.	S1
Oil and gas companies should build long-term community trust in the locations where they extract natural resources.	S19
A thriving oil and gas sector is essential for the economic vitality of rural gas-flaring host communities.	S10

The consensus around distributive, procedural, and recognition normative positions, support/non-support for zero-flaring in S6, S13 and S17, and utterances from the exit interviews indicate a growing awareness of gas flaring's negative impact on the natural environment and a desire to accelerate low-carbon energy transitions as a result. However, disagreement and neutrality across all perspectives relating to government subsidisation of oil and gas production S6 show equivocation over the role of government in sponsoring gas as a bridge fuel (or as means to ameliorate energy security of supply) [89]–[91]. This equivocation is likely reflective of the diversity of stakeholders in the P-set, including strong oil and gas industry representation.

Although voluntary disclosure of gas flaring emissions by IOCs is desirable, S13, the quality of such GHG emissions reporting remains controversial. Empirical analysis of voluntary disclosure reveals that shareholders often react reflexively by superficially enhancing disclosure only under conditions of public controversy and enhanced public scrutiny [92]–[96]. Near-universal agreement about S13 suggests that disclosure of gas flaring emissions by IOCs is crucial. Ensuring mandatory environmental reporting whereby all data on gas flaring emissions, health impacts and distribution patterns are publicly available, e.g., S17, may also potentially benefit market valuation [97]. Accordingly, agreement across all perspectives regarding S13 and S17 indicates a desire for greater transparency of information provided to the public as a matter of procedural justice.

Moreover, rent-seeking linked to the oft-discussed “resource curse” has been and still is a major concern for oil and gas-producing countries. A persistent lack of transparency, industry accountability, and substantial revenue accumulation by influential groups or individuals [98] raises questions concerning political will to curb gas flaring. However, perspectives show some disagreement that rent-seeking (implying non-support) across perspectives A, B and D, and slight agreement by C on rent-seeking/corruption and lack of transparency (components of the resource curse) contradicts some existing studies, e.g., [80], [99]–[102]. Neutrality on perspective A and overwhelming ranking by perspectives C and D for S1 are further indicative of an existential lack of transparency and accountability in the global oil and gas sector. However, there is a global standard to enhance transparency and accountability in the form of the Extractive Industries Transparency Initiative (EITI) [103].

There was agreement that oil and gas were no longer essential to community social development S10. Moreover, the unequal distribution of benefits and burdens of oil and gas extraction actively damage social development – as energy injustice is associated with violent conflict, environmental degradation, displaced communities, and diminished democratic governance globally [104], particularly in unitary states with low levels of regulatory compliance [84], [87], [105]. If the risks of gas flaring are construed as being exaggerated by domestic policy authorities S15, this may lead to recognition injustice as host communities become deliberately excluded from governance mechanisms, resulting in economic losses, environmental burdens, and social deprivation.

4.5.2. Areas of Disagreement

From the z-scores analysis, *n=17* statements constituted points of disagreement identified as *distinguishing statements* (highlighted * in the descriptions)[2]. Notably, eight statements represented areas of disagreement which indicate embedded conflicts over support/non-support

[2] Statements constituted points of disagreement identified as distinguishing statements (highlighted with * in the descriptions).

for gas flaring and the four tenets of justice, reflecting critical areas of clear discursive conflict across all four perspectives (Table 4.6).

Table 4.6: Q-sort statements and numbers of critical areas of clear discursive conflict across all four perspectives extracted from table 4.3.

Statement	Statement No.
We should reduce the amount of waste gas in order to improve profitability in extraction.	S2
The dangers of gas flaring are exaggerated.	S15
Current environmental protections from oil and gas flaring sufficiently balance ecological costs and economic benefits.	S7
Action taken on rent-seeking and corruption should be the first step in tacking gas flaring.	S12
Governments should set up an independent community watchdog group and an advisory group of community leaders to examine, monitor and review government regulatory agencies and the activities of international oil companies.	S21
Oil and gas companies should be mandated to complete a full EIA for any activities where gas flaring will occur.	S24
Global gas flaring produces avoidable emissions, and legislation should stop such practices.	S35
Governments need to protect communities from feeling dispossessed of their land and livelihoods.	S28

There are several important distinctions between the four perspectives relating to support or non-support for continued gas flaring operations, highlighted by statements S2, S15, and S7. There is a noticeable disagreement between perspective A relative to B, C and D on S2 with

Q-sort values (-1 +3 +2 +1)[3]; perspective B relative to A, C and D on S15 with Q-sort values (-5 +1 -2 -4); and perspective B relative to A, C and D on S7 with Q-sort values (-3 +1 -1 -4). On the issues around reducing the amount of waste gas to improve profitability in extraction S2, perspectives B, C, and D agree, while A slightly disagrees. Since S15 presents the dangers of gas flaring as being exaggerated, it also maintains similarities in ranking with the view that the current environmental protections from oil and gas flaring sufficiently balance the ecological costs and economic benefits S7. These disagreements across the perspectives provide context to their relevant support or non-support for gas flaring operations. Of note is the relative utilitarianism presented in defining support/non-support positions, specifically with regard to a desire to *balance* flaring economic benefits at the national scale against environmental and social development burdens at the host community scale. As stated by respondent 3:

> *"My choices are based on balancing the benefits and trade-offs of gas flaring when comparing its socio-economic benefit with the long-term environmental impact on the environment. The statements about who should be responsible for legislation and how much self-regulation is acceptable stood out because it is quite obvious that profit-driven establishments are not very good at looking at anything else".*

Furthermore, respondent 2 stated:

> *"The oil and gas business is necessary for the economic growth of the world. It can, however, be done more responsibly. The industrialised western world is driving the climate agenda while the developing countries in Africa and Asia need the oil and gas to grow and become fully industrialised".*

Further discursive disagreement arises across statements S12, S21, S24, and S35. Regarding S12 with Q-sort values (-2 -3 +1 -1), perspectives A, B, and D disagree with the claim that acting on rent-seeking and corruption is the first step in tackling gas flaring. While perspectives A, B, and D's disagreement on S12 tend to prioritise economic benefit over gas flaring reduction, perspective C slightly agrees that rent-seeking and corruption are the key issues to address. Furthermore, there is a conflict concerning S21 with Q-sort values (+1-3 +1 +2). It emphasises that governments should set up independent community watchdog groups and

[3] Numbers in the brackets are Q-sort values extracted from table 3.

advisory forums of community leaders to examine, monitor and review government regulatory agencies and the activities of international oil companies.

There is a clear distinction between perspectives B versus A, C and D on this issue of community-led independent governance arrangements. Advocates of perspectives A, C and D support this initiative, while perspective B advocates for the status quo. On S24 with Q-sort values (+2-3 +3 +4), perspectives A, C and D largely support mandating oil and gas companies to complete a full EIA for any activities where gas flaring will occur, but B again disagrees. On S35 (+4 +5 +1 -3), regarding employing legislation to stop global gas flaring, which constitutes avoidable emissions, perspectives A, B, and C overwhelmingly support this assertion, but D disagrees. Similarly, on S28 (+3 -2 +2 +2), disagreement emerged between perspective B relative to A, C and D on the issue of the government's responsibility in protecting communities from becoming dispossessed of their land and livelihoods. Again, while perspectives A, C and D support this perspective, B disagrees. For S26 (+2 +3 0 -1), perspectives A and B show support for a national regulatory agency making decisions on managing gas flaring environmental impacts (procedural justice). However, D opposes, and C remains neutral. Across these perspectives, we see a range of responses to the mechanisms of governance desired to ensure transparency, social accountability, the tackling of corruption, and ensuring community cohesion, and regulatory compliance, which underlie overall agreement on the aim to achieve 'good governance' within the oil and gas sector and the authorities that set the regulatory agenda. Further engagement and policy analysis should therefore focus on finding locally-context-sensitive governance mechanisms that achieve this goal.

Disagreement emerges on S3, S26, S29, and S31. S3 (-1 +3 -4 +4) concerns compensation and electricity subsidies for communities affected by gas flaring (an issue of distributive justice), in which perspectives B and D agree, while A and C disagree. This also links to S5 concerning sharing benefits and burdens of natural gas, which C disagrees with. It is interesting to note that perspective C takes a non-egalitarian position, revealing that a redistributive approach is not universally favoured amongst stakeholder groups despite evidence that this improves social development outcomes and the favourability of oil and gas extraction within host communities [5], [7], [8], [79], [106]. There is evidence of modest agreement on S29 (+1 -1 +1 0) that heavy gas flaring nations should directly compensate neighbouring countries for environmental impacts caused by transboundary pollution (an issue of cosmopolitan justice). Though perspectives A and C show modest support, B disagrees, and D is neutral. The final distinguishing point (S31; +3 -2 -1 +1) relates specifically to restorative/cosmopolitan justice, positioning governments to accept responsibility for gas flaring impacts even if privately owned industries cause them. This was a polarising issue. Perspectives A and D support this statement, while B and C again disagree. S31 emphasises guaranteed rights for protection from the impacts of flaring irrespective of who caused them, an issue Hazrati and Hefron [107] discussed as a form of *restorative justice* through which ameliorative compensation mechanisms are offered in the face of environmental risk. Restorative justice is, therefore, worthy of further exploration through heterogeneous stakeholder dialogue to capture the nature and breadth of this polarisation.

4.6. Conclusions and Implications for Future Research

Although gas flaring justice is recognised as a critical environmental governance challenge internationally, there is relatively little assessment of the justice dimensions from the 'bottom-up' from diverse networks of stakeholders involved in industry activity, compliance, regulation, and community engagement. A global justice-focused approach to gas flaring gives an expanded conceptual perspective on the injustices suffered and possible solutions, as demonstrated by this study. Q-method is a valuable tool in studying such issues *of empirical ethics* – an approach whereby social science data is used to clarify and contextualise normative moral positions on, in this case, the energy justice dimensions of global gas flaring. Q-method offers insight into diverse stakeholder positions on controversial issues, uncovering the shared logic behind such positions. Our Q-method analysis identified four normative perspectives: a) government-led zero flaring policy, b) multi-scalar economic governance, c) business responsibility and social license to operate, and d) localism and community empowerment. The largest number of Q-sorters loading on perspective A shows a common aspiration for zero gas flaring globally, a desire for greater outreach and awareness-raising of the core social and environmental impacts of flaring, and legislative practices to actively halt emissions. These features collectively represent fundamental conflicts around global gas flaring perception, structured and negotiated by different stakeholders.

When examining the interplay of the four tenets of energy justice embedded in the Q-statements, we find that: firstly, there is broad overall stakeholder support for zero routine flaring (ZRF) globally across the perspectives. This indicates support for existing policies (ZRF) by 2030 and zero emissions by 2050 captured in post-Paris climate policy. Though our sample is not demographically representative, the diversity of stakeholder positions and backgrounds indicates the *discursive dominance* of zero flaring in future oil and gas governance. Second, we find support for coordinated multi-scalar governance in response to the energy injustices identified. Linking international-national-local regulatory authorities is desired to protect marginalised communities. Third, egalitarian rights-based approaches are generally prioritised over utilitarian approaches, e.g., risk-benefit calculations to define the acceptability of policy approaches or consideration of population density in planning for oil and gas extraction. Fourth, business responsibility necessitates emphasis upon corporate transparency and accountability – specifically transparent communication of flaring activities and impacts and commitment to the Polluter Pays Principle of environmental redress/restorative justice to ameliorate the impacts to affected host communities. Finally, we find that stakeholder disagreement principally centres upon the practical mechanisms to achieve egalitarian just outcomes rather than the core principles of justice underlying a zero-flaring policy approach. These mechanisms vary substantially: covering mechanisms of community compensation (e.g., subsidised electricity and transboundary governance of compensation), the role of local authorities in governance and regulatory compliance, regulatory design (including Environmental Impact Assessment), and the right mechanisms to tackle rent-seeking and corruption. We conclude, therefore, that further negotiation on the implementation of gas flaring elimination, rather than the goal itself, is needed, through careful stakeholder dialogue and negotiation.

Finally, the four specific tenets of energy justice we examined are not the only justice issues associated with flaring. However, our findings underpin the overarching rationale for a net zero routine flaring target, a goal supported across a range of policy, NGOs, and industry stakeholder perspectives. Where zero-flaring is impossible, it is morally necessary for policy and industry actors to not only minimise social and environmental burdens to vulnerable communities, but also to make such burdens socio-culturally 'visible' and distributed equitably based on representative and participatory decision-making processes backed by adequate regulatory mechanisms such as EIA. If natural gas is to play a crucial role in the transition and global climate change mitigation strategies across the world, it will also require stakeholder buy-in to proceed in a just, sustainable, and more equitable way. We suggest therefore a series of policy proposals to prevent or minimise injustice associated with gas flaring based upon the findings of the Q-method analysis, shown in Table 4.7.

Table 4.7**:** Policy proposals emerging from Q-methodology analysis of stakeholders' perspectives on global gas flaring and energy justice.

Concept	Statement Example	Policy proposal
Distributive justice	Communities affected by gas flaring should be compensated with subsidised electricity, S3.	Extend electricity subsidies to gas-flaring host communities.
	The benefits and burdens of gas flaring should be shared fairly between rich and poor communities, S5.	Require IOCs to increase the use of local materials and labour or share more benefits with host communities.
	Action taken on rent-seeking and corruption should be the first step in tackling gas flaring, S12.	Improve transparency, including involving the public in gas flaring projects and providing information on how locally affected people can meaningfully participate in decision-making.
	Gas flaring is a problem when the industry is dominated by international capital, and oil and gas companies extract the value of the gas to another country, S16.	Both the governments of gas flaring nations and IOCs should increase the use of local materials, supply chains, and labour.
	Oil and gas companies should voluntarily adopt the polluter pays principles offering compensation and funding for environmental remediation, S30.	The governments and IOCs are to compensate host communities consistently and proactively to avert civil conflict and unrest.
Procedural justice	To tackle gas flaring, we should improve transparency and industry accountability in the global oil and gas sector, S1.	Improve transparency by implementing the Extractive Industries Transparency Initiative (EITI).

	The environmental impacts of oil and gas flaring are experienced locally and should therefore be managed by local authorities, S11.	Equitably include host communities in gas flaring policies and decision-making.
	Host communities' concerns about gas flaring impacts should be integrated into governments' oil and gas exploration and development decisions, S20.	Integrating host communities' concerns about gas flaring into governments' oil and gas exploration and development decisions.
	Governments should set up an independent community watchdog group and an advisory group of community leaders to examine, monitor and review government regulatory agencies and the activities of international oil companies, S21.	Relevant public authorities should set up independent watchdog groups to examine, monitor and review government regulatory agencies.
	Oil and gas companies should be mandated to complete a full Environmental Impact Assessment for any activities where gas flaring will occur, S24.	Mandate IOCs to complete a full Environmental Impact Assessment (EIA).
Recognition justice	Oil and gas companies should build long-term community trust in the locations where they extract natural resources, S19.	Enable genuine integration with the various gas flaring host communities. Host communities should be fairly and adequately represented in gas flaring processes. Avoid the use of physical threats by the states and support dialogue with host communities.

	Governments need to protect communities from feeling dispossessed of their land and livelihoods, S28.	Engage with indigenous peoples as fully recognised and respected stakeholders in the gas flaring initiatives occurring within local host communities.
Cosmopolitan justice	It is acceptable for gas flaring to take place in areas of low population density, S27.	Gas flaring often takes place in *sacrifice zones* – places populated by economically and politically vulnerable communities, in which collective benefits to the economy as a whole (i.e., the extraction of energy resources for global commodity sale) are produced at the expense of the local environment and the community it supports. Carefully manage gas flaring pollution in sacrifice zones. Give host communities control of their land. Governments and IOCs should provide clean and accessible water services for host communities within the sacrifice zones.
	Heavy gas flaring nations should compensate neighbouring countries for environmental impacts caused by transboundary pollution, S29.	Facilitate international mechanisms/domestic policies to tackle transboundary pollution and other global externalities.
	Governments should accept responsibility for gas flaring impacts, even if privately owned industries cause them, S31.	Governments should reconsider and facilitate the restoration of degraded host communities through preventive and forward-thinking actions.

4.6.1. Note on The Use of Q-Methodology and Future Research

Q-methodology has distinct advantages for empirical ethics research into energy justice as it requires a small sample size to generate statistically significant results with participant-driven characterisation of normative positions. Q-methodology can reduce researcher bias associated with predefined questions on quantitative surveys or highly structured interview protocols. However, there are some limitations to this research. Firstly, the top-two gas flaring nations (Russia and Iraq) were not represented in the P-set despite efforts to secure such contacts. Secondly, Q-methodology requires short, accessible statements to facilitate analysis [66], losing some of the richness of qualitative data. However, the exit interviews enabled us to bring this qualitative richness back to contextual the meaning of the aggregate perspectives produced through Q-analysis. Thirdly, the four factors had an explained variance of 58% (the threshold is 50%), leaving 42% of the total data unexplained. Finally, Q methodology is based on purposive/snowball sampling techniques of a small-*n* P-set. We used purposive/snowball sampling. As such, participants were allowed to enter the survey with or without a code to encourage participation due to the nature of the survey. In one instance, participants re-forwarded the survey link to people they believed were familiar with the topic. Two participants entered the survey without a code to remain anonymous.

We note that as is common to Q-method studies, data is representative of the broader *discourse* concerning the topic rather than of a specific demographic, so the findings cannot be generalised to a larger population. Further quantitative survey evaluation of these perspectives tested amongst a demographically representative population would provide generalisable findings at the population level.

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Chapter 5

Optimising policies and regulations for zero routine gas flaring and net zero

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Abstract

Global policy actions to reduce the environmental and social impacts of gas-flaring are primarily derived from voluntary arrangements. This paper evaluates stakeholder preferences for different policies and regulatory options, determining the most optimised and effective to help eliminate routine gas-flaring by 2030 and achieve net zero emissions by 2050 whilst addressing good governance, justice, and fair implementation. Its mixed methods incorporate literature and document review, interviews, expert surveys, Analytical Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (G-TOPSIS), deriving two competing perspectives on gas flaring policy strategy, with differences revealed through the AHP ranking process of individual criteria. All criteria and sub-criteria identified were integral to achieving the flaring and emissions targets, with "policy and targets" and "enabling framework" the most important individual criteria. The "background and the role of reductions in meeting environmental and economic objectives" and "nonmonetary penalties" were the most crucial sub-criteria. G-TOPSIS showed that fully implementing gas-flaring policies and regulatory framework criteria to limit warming to 1.5°C is the most effective policy alternative. Globally coordinated, uniform and reciprocal legally binding agreements between countries to supplement national initiatives are imperative to improve the effectiveness of country-specific gas flaring policy strategies.

Keywords: environmental regulations, environmental policy, Implementation, AHP, G-TOPSIS, multicriteria analysis, air pollution

5.1. Introduction

Oil and natural gas development often involve flaring and venting during drilling, production, gathering, processing, and transportation operations. Gas flaring burns excess natural gas and oxygen at the wellhead during oil exploration and development, a technique used for emergency relief, overpressure, process upsets, start-ups, shutdowns, and other safety-related operational purposes. Though posited as a routine industry practice, gas flaring is a major contributor to global climate change through the emission of CO_2, methane, and black carbon (IEA, 2022; Johnston et al., 2020; Motte et al., 2021). The World Bank estimates that over 400 million tonnes of CO_2 were emitted in 2021 from gas flaring – equivalent to the emissions produced by 9 trillion miles of car journeys. An estimated 10,000 gas flares are burning globally at any given time, with the wasted gas burnt having the potential to power the whole of sub-Saharan Africa (GGFR/The World Bank, 2022). With natural gas prices at historic highs, gas flaring is an extraordinary waste of economic value, amounting to USD 55 billion per year at USD 10 per MBtu (IEA, 2022).

Gas flaring has negative environmental and public health impacts. These include terrestrial acidification through sulphur dioxide, nitrogen oxides, and other acidic gas releases (Dung et al., 2008; Motte et al., 2021), causing air pollution and concomitant health risks, including headaches, tremors, irregular heartbeats, cancer, eye and liver damage, respiratory disease, heart disease, and strokes (GGFR/The World Bank, 2022; Johnston et al., 2020), skin cancers, and stomach ulcers from contaminated water (Ite and Ibok, 2013; Soltanieh et al., 2016). People living near oil and gas locations are at higher risk of exposure (Ialongo et al., 2021; Lee et al., 2022), making this a significant environmental justice issue (Aigbe, Cotton, et al., 2023). Despite these negative impacts, efforts to abate flaring remain challenging from a policy and regulatory perspective.

Global policy on gas flaring reduction has had limited impact. The World Bank/GGFR (2021) estimated 143 bcm of natural gas was flared in 2020, with the top seven gas flaring countries that produce 40% of the global oil and gas annually accounting for 65% of the total. In 2021 alone, flaring activity led to the direct release of 270 Mt of CO_2 and approximately 8 Mt of methane (240 Mt CO_2-eq) with black soot and other GHGs into the atmosphere (IEA, 2022). Action to reduce these high volumes of atmospheric pollutants is primarily through voluntary policy programmes and initiatives. Notable is the Zero Routine Flaring by 2030 (ZRF) initiative, a voluntary policy platform created by the World Bank and the United Nations in 2015. To date, 35 governments, 53 oil companies, and 12 development institutions have endorsed the ZRF initiative, though enforcement remains dependent upon domestic environmental regulation. The Global Gas Flaring Reduction Partnership (GGFR) is also a voluntary programme, providing technical support and guidance to countries to measure, report and verify their gas flaring emissions and facilitate stakeholder cooperation to address environmental impacts. The GGFR also supports the ZRF initiative and projects that aim to capture and utilise methane from oil and gas operations, such as the Global Methane Hub (GGFR/The World Bank, 2022, 2023; IEA, 2021, 2022). Signatories to the Paris Agreement have also included strategies to minimise gas flaring as part of their Nationally Determined Contributions (NDCs), such as capturing associated gas, implementing regulations or fees, or promoting alternative energy sources. The most recent NDC synthesis report (2022) integrates information from the 166 latest available NDCs and represents 193 Parties to the Paris Agreement (UNFCCC, 2022). According to the UNFCCC 2022 report, the current commitments will lead to a 10.6% increase in emissions by 2030 compared to 2010. However, for the current NDC implementation to lower emissions below the present policy scenario, the net zero emissions by 2050 target will require more realistic measures and policies (Den Elzen et al., 2019). The updated NDC synthesis report and other research project emissions to increase temperatures to 1.5°C if emissions are reduced by 45% by 2030 compared to 2019. Limiting warming to 2°C by 2030 requires a 25% reduction in emissions; whereas a business-as-usual scenario sets the path for 2.7°C warming by the end of the century (Ma et al., 2018, 2019; Yin et al., 2020; Patra et al., 2021; Tian et al., 2021; UNFCCC, 2021, 2022; Qin, 2022). The current CO_2 and gas flaring reduction trajectories of 5.8% and 5% (IEA, 2021; GGFR/The World Bank, 2023), respectively, have further positioned the NDCs as presenting a huge gap between intention and action (Kharbach and Chfadi, 2022; Teng, 2022).

One of the key challenges is that oil and gas companies (and their investors) place relatively low importance on voluntary emissions reduction programmes in favour of investment that conforms to mandated legislative and regulatory practices (Lutsey and Sperling, 2007; Alsaifi, Elnahass and Salama, 2020), particularly when profit is prioritised over emission reduction (Friedman, 1970, 2007). In the absence of stronger global governance on flaring and the translation into domestic regulatory practice, countries without oil and gas resources will likely continue to lobby for more stringent policies and functional regulatory frameworks in low-income developing oil and gas-producing nations (Jost, Dale and Schwebel, 2019). However, these will be met by oil and gas companies lobbying against such measures leading to, as Rezessy and Bertoldi (2011) found, poor domestic regulatory compliance, monitoring, and reporting. Approaches to the problem are debated. Raders (2012), for example, argues for more decisive legislative action on mandatory measurement and reporting of flaring, whereas Li (2017) suggests that voluntary disclosure programmes combined with regulation may support higher incentives for firms to invest in cleaner technology. Broader contextual factors such as economic and technical feasibility, international aid, responsibility and equality, public perceptions, stakeholder engagement, international pressure, and domestic political negotiation amongst coalitions of interest all influence the failure or success of flaring reduction (Zheng et al., 2021). Thus, there is a need to combine policy action through multi-scalar initiatives that link international cooperation, national legislation, and local action (Aigbe et al., 2023; Siriwardana & Nong, 2021).

5.2. Political Barriers to Gas Flaring Reduction

The political barriers to gas flaring reduction involve a combination of state and industry actors influencing policy outcomes, environmental laws, and implementation measures (Willyard, 2019). Fossil fuel lobbying interests produce a range of institutional challenges and policy deficits (Scheren et al., 2002; Giwa, Nwaokocha and Odufuwa, 2017), (re)producing failures of institutional capability to meet environmental protection goals (Hassan and Kouhy, 2013; Nelson, 2015; Nelson et al., 2017; Korppoo, 2018; Olujobi, 2020; Olujobi et al., 2022). Within oil and gas-rich developing nations, rent-seeking, the resource curse, and a persistent lack of transparency and industry accountability serve to weaken flaring abatement policies and regulations (e.g., Watts, 2004; Ackah-Baidoo, 2012; Idemudia, 2012; Goumandakoye, 2016; Symons, 2016; Apergis and Katsaiti, 2018; Oduyemi, Owoeye and Adekoya, 2021). Policy action is further stymied by the complex challenge of infrastructural “lock-in” to carbon-intensive economic activity (Mattauch et al., 2015; Unruh, 2000, 2019; Unruh & Carrillo-Hermosilla, 2006; Ylä-Anttila et al., 2018), often leading to endorsement of flaring as a positive economic development measure (Akinola and Wissink, 2018; Iornumbe, 2019; Benson, 2020; Olujobi, 2020) despite issues of resource waste, transboundary air pollution (Torre et al., 2021; Varkkey, 2019), and the geopolitical risks of fossil fuel reliance for energy security in the wake of Russia’s invasion of Ukraine.

Failure to establish coherent environmental policies and regulatory measures has remained a hindrance to flaring reduction (Altamirano-Cabrera et al., 2013; Ialongo et al., 2021; Loe & Ladehaug, 2012; Rodrigues, 2022; Shahab-Deljoo et al., 2023; Soltanieh et al., 2016; Wen et al., 2023). There have been failures in the overall design and implementation of gas flaring policies, incoherent legislative and regulatory frameworks, non-transparent reporting, and disclosure of statistical data, and in providing an enabling flaring framework including, e.g., fiscal and emission reduction incentives (Agbonifo, 2016; Babalola & Olawuyi, 2022; Bello, 2023; Fawole et al., 2016; Gerner et al., 2004; Mrabure & Ohimor, 2020; Svensson, 2005; Zhizhin et al., 2021). Outdated legal and regulatory provisions, in turn, contribute to the difficulty in monitoring and enforcing existing regulations (Buzcu-Guven & Harriss, 2014; Korppoo, 2018; Nelson, 2018; Olujobi, 2020; Olujobi et al., 2022; Olujobi & Olusola-Olujobi, 2020; Radhakrishnan et al., 2023) and ultimately ineffective penalties (usually fines) for breaching such regulations (Castelo Branco et al., 2010; Korppoo, 2018; Wen et al., 2023).

Gas flaring creates global externalities from associated greenhouse gas emissions, leading to local and global environmental injustice. Economic development policy decisions create transboundary pollution flows, influencing other countries' environmental management policy choices (Millimet, 2013). Consistency and policy coherence across oil and gas producer and non-producer nations participating in flaring reduction initiatives is a key policy goal. However, flaring mitigation policies have been approached primarily through individual country-level arrangements with concomitant effects on global environmental justice (Aigbe, Cotton, et al., 2023). A multi-level governance approach that fosters international cooperation and solidarity is desirable in ensuring fair and just emission reduction efforts based on shared goals and principles (IPCC, 2022; Nabernegg et al., 2019) in a way that addresses international and national needs.

This empirical analysis aims to address the barriers to effective gas flaring reduction, addressing issues of governance, energy justice, and implementation through empirical research with key stakeholders across the oil and gas policy and industry sectors. Selecting suitable gas flaring policies and regulatory framework criteria options to reduce the impact of climate change is complex. Hence, it necessitates an appropriate methodological approach for policy framing that can manage several alternatives. Analytical Hierarchy Process (AHP) has been ranked among the top multi-decision criteria analyses (e.g., Pohekar and Ramachandran, 2004; Kumar et al., 2017) and presents a suitable platform for decisions involving criteria alternatives (Buckley, 1985; Saaty, 1994; Saaty and Vargas, 2012). The G-TOPSIS is also highly regarded for its ability to adapt to various situations and requirements. In uncertain decision-making, G-TOPSIS can enhance decision-making precision (Arabameri et al., 2020).

Combining the AHP and G-TOPSIS methods offers a robust and efficient model for conducting social science research on global gas flaring and energy. We combine these approaches to:

1. Identify the key criteria and sub-criteria that can overcome the barriers identified, considering alternative gas flaring policies and regulatory framework scenarios to meet the 2030 zero routine flaring targets.
2. Evaluate, prioritise, and benchmark these criteria, sub-criteria, and alternative policy scenarios to stimulate flaring reduction actions, and
3. Derive optimal gas flaring policy framework criteria and sub-criteria from our analysis, presenting the best alternative policy scenario to stimulate flaring reduction actions.

5.3. Research Methodology

The identification of criteria and sub-criteria for analysis using AHP and G-TOPSIS begins by reviewing extant policy literature and regulatory instruments relevant to global gas flaring reduction. We developed a corpus of policy materials that provide four alternatives. These alternatives consider both the Stated Policies Scenario (STEPS), which considers only specific policies in place or have been announced by governments and the Announced Pledges Case (APC), which assumes that all announced national net zero pledges are fulfilled fully and on schedule, whether supported by specific policies. The alternatives were derived from the following reports, forecasts, and scenarios, considering the following factors:

1. The current global CO_2 reduction trajectory of 5.8% (IEA, 2021, 2022).
2. The current global gas flaring reduction trajectory of 5% (GGFR/The World Bank, 2023).
3. Remaining on course with the IEA (NZE by 2050) scenario necessitates eliminating all non-emergency flaring globally by 2030, translating into a 90% reduction (IEA, 2022a).
4. Limiting temperature rises to 1.5°C in model pathways with no or limited overshoot of 1.5°C, then global net anthropogenic CO_2 emissions decline by about 45% from 2010 levels by 2030 (Ma et al., 2018, 2019; Patra et al., 2021; Qin, 2022; Tian et al., 2021; UNFCCC, 2021b; Yin et al., 2020).
5. Limiting global warming to below 2°C by 2030, where emissions are projected to decline by about 25% by 2030 in most pathways (Ma et al., 2018, 2019; Patra et al., 2021; Qin, 2022; Tian et al., 2021; UNFCCC, 2021b; Yin et al., 2020).

6. The current IEA projections estimate that if annual CO_2 emissions trends continue to increase from 34 Gt in 2020 to 36 Gt in 2030 and remain on the same trajectory until 2050, the global average surface temperature is expected to rise by around 2.7 °C with the business-as-usual scenario (IPCC, 2018b; IEA, 2021).

AHP and G-TOPSIS were then used to assess the most critical criteria/sub-criteria and feasible alternative scenarios to meet these demands. To address this, the research involved three phases.

Phase 1: Identify the key criteria and sub-criteria. An extensive literature review was conducted to identify the significant gas flaring policies and potential regulatory criteria and sub-criteria (Table 5.1). Journal articles, gas flaring and energy reports, official government policy documents, and gas flaring regulatory frameworks were searched with the keywords *gas flaring AND policies OR regulations OR barriers*. Policy articles were sourced through the Google search engine; academic articles were sourced from Scopus. The corpus was limited to publications written in English without any limitations on the year of publication. We only included articles and reports that met these inclusion criteria, resulting in a selection of 35 articles and reports. Contents that did not meet these requirements were excluded. Published energy reports were reviewed, including those from the GGFR and The World Bank.

We supplemented the written corpus with qualitative data from in-depth semi-structured interviews, expert perception surveys and knowledge/expert surveys with academics/industry experts, industry stakeholders/scientific, oil and gas industry, directors, law, regulatory, governmental and NGO stakeholders, energy consultants, and citizen stakeholders across the top 15 gas flaring countries globally. Drawing on this information and 8 objective reports/data from the Global Gas Flaring Reduction Partnership (GGFR) and World Bank consultations in 2002, 2004, 2009 and 2022, we finalised and categorised the main criteria and sub-criteria pertaining to gas flaring policies and regulatory frameworks.

Phase 2: Evaluate, prioritise, and benchmark gas flaring policies and regulatory frameworks using the Analytical Hierarchy Process (AHP). A pair-wise comparison matrix was performed to compute the weights of the main and sub-criteria.

Phase 3: Derive optimal gas flaring policy framework criteria and sub-criteria by selecting the best alternatives using the G-TOPSIS approach. G-TOPSIS involves basic calculations and a short computation time, ranks the alternatives, incorporates quantitative and qualitative criteria, and determines the relative importance of alternatives and compliance with the constraints. G-TOPSIS is valued for its local and experimental nature and is well-suited to various situations and requirements (Arabameri et al., 2020). The G-TOPSIS method was employed to find the best solution from four available alternatives (scenarios) to meet ZRF by 2030 and NZE by 2050. These methods are detailed below and in Figure 5.1, following Saaty (1987, 1990) and Liu, Yang and Forrest (2017).

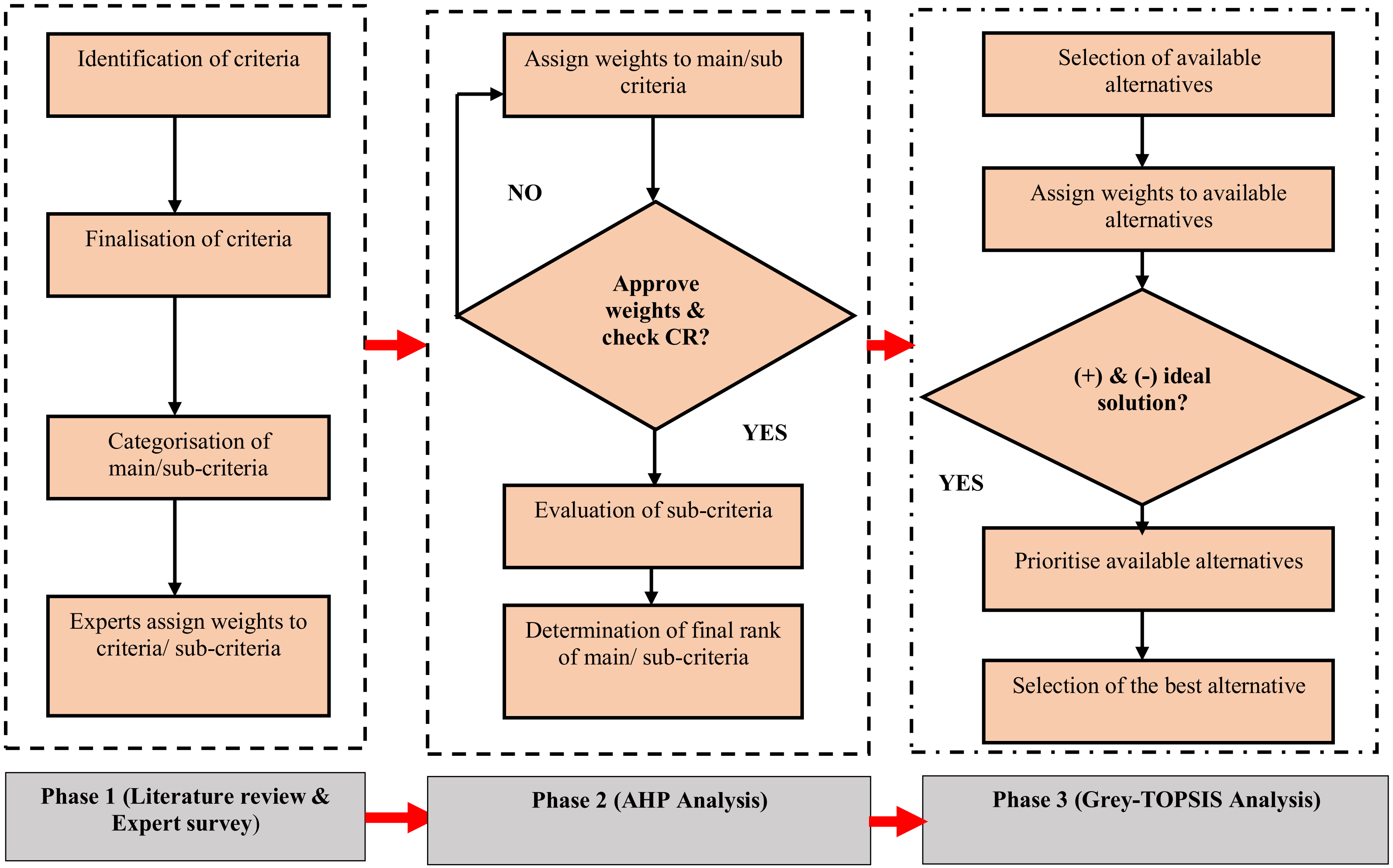

Figure 5.1. Process flow showing the different research phases in developing alternative policy and regulatory options.

Table 5.1. Categorisation of criteria in global gas flaring policies and regulations.

Main Criteria	Details of each criterion	Sub-Criteria	References
Policy and targets	Gas flaring and venting policies, abatement and targets are set to avoid resource wastage and reduce local air pollution and GHG emissions. A bottom-up approach to setting sector-specific targets is necessary where no national flaring targets exist.	• Background and the role of reductions in meeting environmental and economic objectives • Targets and limits specified by the regulator	(Agbonifo, 2016; Aghalino, 2009; Babalola & Olawuyi, 2022; Buzcu-Guven & Harriss, 2014; Elvidge et al., 2018; Gerner et al., 2004; GGFR/The World Bank, 2002b, 2002a, 2004c, 2004b, 2004a, 2009, 2022a, 2022b; Hassan, 2020; Hassan & Kouhy, 2013; Ialongo et al., 2021b; Karasalihović Sedlar et al., 2018; Korppoo, 2018; Loe & Ladehaug, 2012; Okafor & Aniche, 2016; Osuoha & Fakutiju, 2017; Rodrigues, 2022; Shahab-Deljoo et al., 2023; Soltanieh et al., 2016; Wen et al., 2023)
Legal, regulatory framework, and contractual rights	Gas flaring legal, regulatory framework and contractual rights are usually anchored in national or local legislation governing the jurisdiction of the oil and gas sector and environmental management.	• Primary and secondary legislation and regulation • Legislative jurisdictions • Associated gas ownership	(Agbonifo, 2016; Aghalino, 2009; Babalola & Olawuyi, 2022; Buzcu-Guven & Harriss, 2014; Castelo Branco et al., 2010; Elvidge et al., 2018; Gerner et al., 2004; GGFR/The World Bank, 2002b, 2002a, 2004c, 2004b, 2004a, 2009, 2022a, 2022b; Hassan, 2020; Hassan & Kouhy, 2013; Korppoo, 2018; Okafor & Aniche, 2016; Osuoha & Fakutiju, 2017; Rodrigues, 2022; Shahab-Deljoo et al., 2023; Soltanieh et al., 2016; Wen et al., 2023)
Regulatory governance and organisation	Regulatory governance and organisation criteria define which institutions have regulatory authority over the oil and gas industry – a factor essential to clearly define, along with the scope of their mandates and	• Regulatory authority • Regulatory mandates and responsibilities • Monitoring and Enforcement • Development plans • Economic evaluation	(Agbonifo, 2016; Aghalino, 2009; Babalola & Olawuyi, 2022; Buzcu-Guven & Harriss, 2014; Elvidge et al., 2018; Gerner et al., 2004; GGFR/The World Bank, 2002b, 2002a, 2004c, 2004b, 2004a, 2009, 2022a, 2022b; Hassan, 2020; Hassan & Kouhy, 2013; Ialongo et al., 2021b; Korppoo, 2018; Okafor & Aniche, 2016; Osuoha

	abatement strategies from the perspective of waste prevention.		& Fakutiju, 2017; Radhakrishnan et al., 2023; Soltanieh et al., 2016)
Licensing and process approval	Regulations on gas flaring and venting depend on how associated gas is treated and oil development rights granted in primary legislation. Approval can be granted through various permits and licenses. The state typically owns underground resources (Canada and the United States are notable exceptions) irrespective of the fiscal regime applicable	• Flaring or venting without prior approval • Authorised flaring or venting	(Agbonifo, 2016; Babalola & Olawuyi, 2022; GGFR/The World Bank, 2002b, 2002a, 2004c, 2004b, 2004a, 2009, 2022a, 2022b; Korppoo, 2018; Olujobi et al., 2022b; PFC Energy/The World Bank, 2007; Rodrigues, 2022; Soltanieh et al., 2016)
Measurement and Reporting	Regulations that prescribe measurement and reporting standards and require companies to record and submit information help monitor compliance, track progress, compare performance, improve poorly performing assets, and identify those needing inspection.	• Measurement and reporting requirements • Measurement frequency and methods • Engineering estimates • Record keeping • Data compilation and publishing	(GGFR/The World Bank, 2002b, 2002a, 2004c, 2004b, 2004a, 2009, 2022a, 2022b; PFC Energy/The World Bank, 2007; Orji, 2014; Agbonifo, 2016; Soltanieh et al., 2016; Korppoo, 2018; Nelson, 2018; Babalola and Olawuyi, 2022; Olujobi et al., 2022; Radhakrishnan, DiCarlo and Orbach, 2023; Wen, Xiao, and Peng, 2023)
Fines, penalties, and sanctions	Most jurisdictions, legislation, and contractual provisions impose sanctions and mandatory payments or other means of enforcement for noncompliance with gas flaring regulations.	• Monetary penalties • Nonmonetary penalties	(GGFR/The World Bank, 2002b, 2002a, 2004c, 2004b, 2004a, 2009, 2022a, 2022b; PFC Energy/The World Bank, 2007; Loe and Ladehaug, 2012; Orji, 2014; Agbonifo, 2016; Soltanieh et al., 2016; Nelson, 2018; Babalola and Olawuyi, 2022; Olujobi et al., 2022; Rodrigues, 2022; Shahab-Deljoo et al., 2023; Wen, Xiao, and Peng, 2023)

Enabling framework	The gas flaring enabling framework includes a range of economic instruments or flaring abatement programs that can be introduced to encourage producers and specifically target gas flaring and venting (e.g., fiscal or market-based incentives).	• Performance requirements • Fiscal and emission reduction incentives • Use of market-based principles • Negotiated agreements between the public and the private sector. • Interplay with midstream and downstream regulatory framework	(Agbonifo, 2016; Babalola & Olawuyi, 2022; Castelo Branco et al., 2010; GGFR/The World Bank, 2002b, 2002a, 2004c, 2004b, 2004a, 2009, 2022a, 2022b; Korppoo, 2018a; Loe & Ladehaug, 2012; N. Nelson, 2018; Olujobi et al., 2022; Orji, 2014; PFC Energy/The World Bank, 2007; Rodrigues, 2022; Shahab-Deljoo et al., 2023; Soltanieh et al., 2016; Wen et al., 2023).

5.3.1 Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) is an established multi-criteria decision analysis technique which assigns weights to compare parameters/alternatives, offering a robust model for decision-making, rating, and prioritising issues, enabling management and formulation of a hierarchical model (Balubaid et al., 2015). AHP provides flexibility in integrating objective value evidence, subjective judgments, and expert knowledge (Pohekar and Ramachandran, 2004). It has been used either as a stand-alone or mixed-method approach (Solangi, Longsheng and Shah, 2021) on a range of environmental policy issues relevant to energy planning (Pohekar and Ramachandran, 2004; Mateo, 2012; Taha and Dain, 2013); and energy sustainability research (Wang et al., 2009; Robles, Haddad, Liazid and Ferreira, 2017; Polo and Ospino, 2017; Chanchawee and Usapein, 2018; Wu, Xu and Zhang, 2018).

Saaty (1990) proposed the following stages, which were applied in the current study:

Stage 1. The development of the hierarchical pattern - decomposing the problem into a hierarchical tree (Saaty, 1994) formed around classifications and specific criteria. Seven main criteria and twenty-four sub-criteria directly linked to global gas flaring policies and regulations were selected and categorised based on consultations held by GGFR/The World Bank between 2004 and 2022 (Table 5.1; Fig. 5.2).

The seven main criteria and twenty-four sub-criteria identified in this study are not the only criteria and sub-criteria in gas flaring policies and regulations. There are others, including governments developing policies specifying the role of flaring and venting reduction, regulatory procedures, regulators are adequately staffed and financed, definitions and boundaries, regulatory approaches, prescriptive approach adopted, performance-based approach adopted, or hybrid approach adopted, autonomy and accountability, regulators independence, participation & predictability, third-party access (TPA) to gas infrastructure (access to up/midstream gas infrastructure). Although these criteria and sub-criteria were identified from various articles and reports, they were consolidated into seven main criteria and twenty-four sub-criteria in the 2022 GGFR/The World Bank consultation. Hence, they were not listed separately to prevent redundancy and repetition.

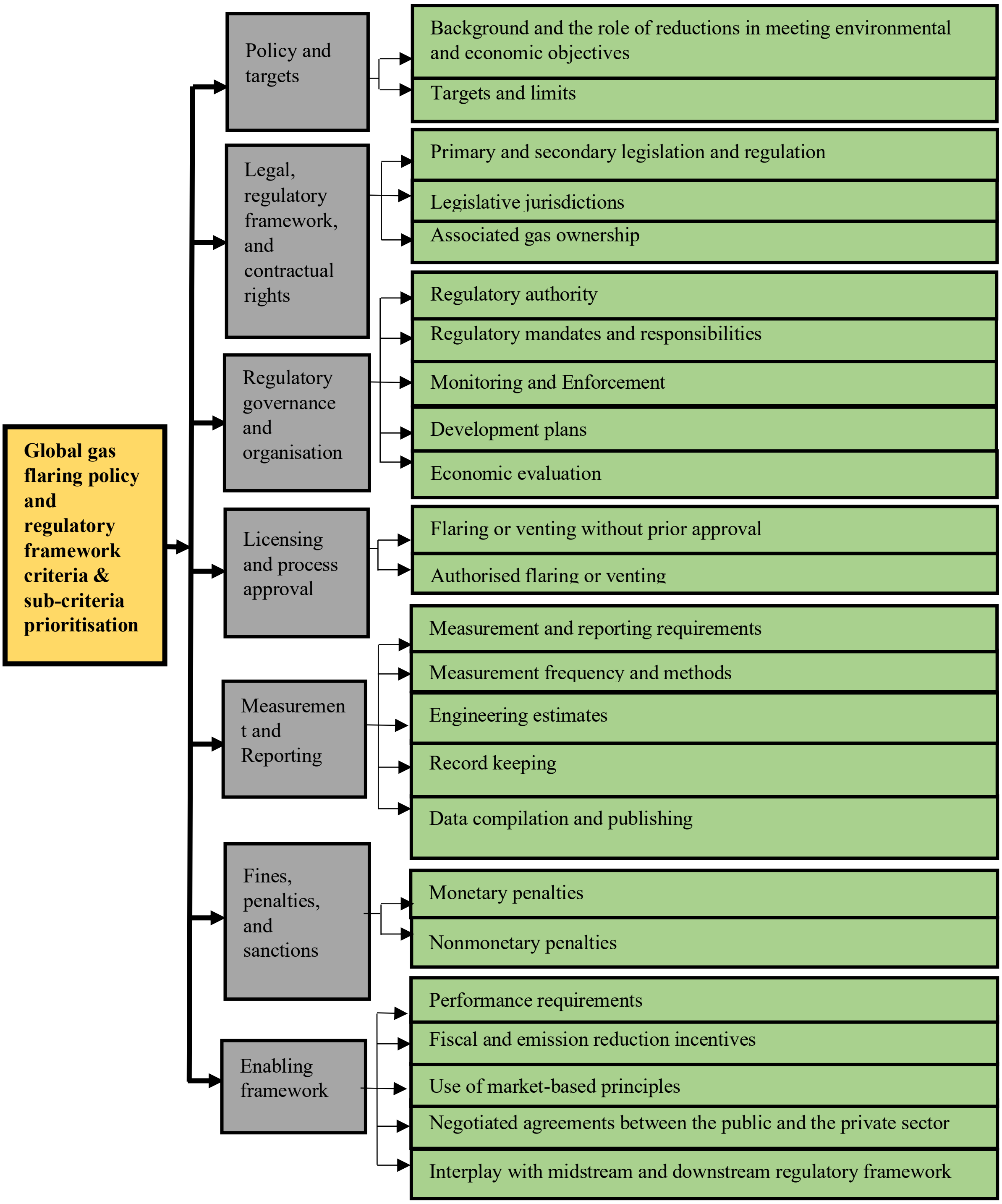

Figure 5.2. The hierarchical structure of criteria and sub-criteria ranking of global gas flaring policies and regulatory framework. The gold box defines and represents the AHP objective. The grey boxes indicate the seven main criteria, while the green boxes denote the twenty-four sub-criteria, showing how they map onto each main criterion.

Stage 2. Assembling expert opinions. The basic Saaty 1–9 AHP scale (Table 5.2) informed the development of a survey of expert participants to provide their opinions. From 120 survey links sent out, 17 people (14.2%) responded (Table5.3). As there is no agreement among researchers on the number of respondents appropriate for a reliable AHP analysis, the method can be used for a wide range of respondents, from one expert to several experts (Ghimire and Kim, 2018). Of note, for example, is the Qureshi and Harrison (2003) study with 13 farmer responses to riparian revegetation policy options. The 17 respondents from the top 15 gas flaring countries represented a highly informed group on global gas flaring policy and regulations. Before the survey, experts were informed about the study's objective, and after providing consent in line with ethical procedures, data was collected through an online survey. The survey questionnaire focused on comparing the main criteria and the sub-criteria to obtain a vector of weights by applying the basic AHP scale (Table 5.2) to each criterion and sub-criterion.

Table 5.2. Saaty's scale of importance for pairwise comparison matrices.

Preference Scores	Definition	Explanation
1	Equally important	Both elements have equal priority.
3	Moderately important	One element is moderately favoured over the other.
5	Strongly important	Experience and judgment strongly recommend preferring one element over the other.
7	Very strongly importance	An element is given a very strong preference over another, and its dominance is demonstrated in practice.
9	Extremely importance	There is the most decisive practicable proof of facts to favour one operation over another.
2, 4, 6, 8	Intermediate weights	These intermediate weights represent a compromise between the preferences listed above.
Reciprocals		Reciprocals are used for inverse comparison.

Respondents were asked to engage in a pairwise comparison and rate the importance of each criterion on a scale of 1 to 9 for all 57 questions. Each question produced two clusters, labelled groups A and B, comprising a mix of respondents. An average response for each question was calculated in both groups' results. The Consistency Ratio (CR) of responses (Saaty 1994) was first checked using the CR Equation (see section d below: Calculation of Consistency Index). As the results would be inaccurate if CR ≥ 0.10, all CRs higher than 0.10 were adjusted, and the comparisons were recalculated. For example, when the CR of criteria or sub-criteria with a score of 4 exceeded 0.1, adjustments were implemented to maintain consistency by assigning a value of either 3 or 5 based on subjective judgment.

Table 5.3. Information on consulted experts

Country	Respondents (*n=17*)
Angola/France/UK/Nigeria	3
Canada	1
Egypt	1
France	3
Germany	1
Iran	1
Mexico	1
Netherlands	1
Nigeria	9
Norway	1
Qatar	1
UAE/Oman/Nigeria	1
UK	3
USA	5
Gender	
Male	15
Female	2
Sector	
Academics/Industry experts	4
Industry Stakeholders/ Scientific	2
Oil & Gas industry	9
Directors, law & regulatory, governmental, and NGO stakeholders	12
Energy Consultancy	1
Ordinary Citizen stakeholder	3
Others	3

Stage 3. Pair-wise comparison and calculation of the relative weights and Consistency Index (CI). The third stage involved four steps.

a. *Develop the pair-wise comparison matrix.* A pair-wise comparison matrix was performed, and the values of the pairwise comparisons were determined using Equation 1. Given a matrix A for n=5 criteria, we have:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & \cdots & a_{mn} \end{bmatrix} \tag{1}$$

b. *Develop the normalised matrix A_1.*

If operation *i* has a number assigned to it relative to *z,* then *z* has the same value as *i*. Hence, we calculated and obtained the Eigenvalue and Eigenvector, and the normalised comparison matrix (A_1) as follows:

$$A_{11} = \begin{bmatrix} a_{11} & a_{12} & \cdots & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & \cdots & a_{mn} \end{bmatrix} \tag{2}$$

$$a_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \qquad for\ i, j \ = 1, 2, 3, \ ....n \tag{3}$$

where n = number of criteria.

$$w = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \quad \text{and} \quad w' = Aw = \begin{bmatrix} w'_1 \\ w'_2 \\ \vdots \\ w'_n \end{bmatrix} \tag{4}$$

c. *Calculation of eigenvalue and eigenvector.*

The inputs in Table 5.1 were applied to produce the ratio scale consistency index as the output, built on the Eigenvector. Defining *X* as the eigenvector, *Xi* as an eigenvalue of the given matrix, and λ_{max} as the largest eigenvalue of the pair-wise comparison matrix, we calculated:

$$\lambda_{max} = \frac{1}{n}\left(\frac{X'_1}{X_1} + \frac{X'_2}{X_2} + \ldots \frac{X'_n}{X_n}\right) \tag{5}$$

d. Calculation of Consistency Index (CI).

The fourth step of the AHP analysis involved checking the CI calculation. A matrix (A_1) for comparing objectives and criteria was formed in pairs. During the review of respondents' opinions, relative judgements (numbers allocated to criteria/sub-criteria) were combined and averaged to form a matrix of comparative judgment for opinions. Thus, the consistency of the pair-wise comparison matrix was calculated as follows:

$$\mathrm{CI} = \frac{\lambda_{max} - n}{n - 1} \tag{6}$$

Here, λ_{max} indicates the eigenvalue, and *n* represents the number of criteria. The consistency ratio (CR) is the ratio of the consistency index CI to the average random index RI. CR is thus given as:

$$\mathrm{CR} = \left(\frac{\mathrm{CI}}{\mathrm{RI}}\right) \tag{7}$$

The value of RI is based on the average consistency of square matrices of the number of observed criteria *n* with its corresponding assigned RI value where RI indicates the random index (Table 5.4).

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

CR should be within the threshold of 0.1 for the rankings to be consistent. If CR ≥ 0.1, the results would be inaccurate, and the comparisons were recalculated. The weights of the key criteria and sub-criteria are provided using the AHP approach.

The overall global weights ranking of sub-criteria was calculated by multiplying the local weight of each sub-criterion with its corresponding main criterion. This was done hierarchically, based on the obtained values, which helped us determine the overall importance of each sub-criterion.

5.3.2 Grey Numbers

The interval of the unknown and known values is known as the grey number, which comprises partial or incomplete system data. The grey number is expressed with the symbol $\otimes$. There are several types of grey numbers. Following Liu, Yang and Forrest (2017) and Zare *et al.* (2018), we introduce three types of grey numbers:

Type (1): If $\otimes B$ is a grey number whose lower bound can only be calculated, it is known as a grey number with only a lower bound and is denoted as $\otimes B = [\underline{B}, \infty)$.

Type (2): If $\otimes B$ is a grey number whose upper bound can only be calculated, it is known as a grey number with only an upper bound and is denoted as $\otimes B = (\infty, \overline{B}]$.

Type (3): If $\otimes B$ is a grey number whose lower and upper bounds can be calculated, it is referred to as an interval grey number and is denoted as $\otimes B = [\underline{B}, \overline{B}]$.

If $\otimes B = [\underline{B}, \overline{B}]$ *and* $\otimes C\ [\underline{C}, \overline{C}]$ are two grey numbers, then arithmetic operations can be written on them as Equations (8) - (11):

$$\otimes B + \otimes C = [\underline{B} + \underline{C}, \overline{B} + \overline{C}] \tag{8}$$

$$\otimes B - \otimes C = \otimes B + (-\otimes C) = [\underline{B} - \overline{C}, \overline{B} - \underline{C}] \tag{9}$$

$$\otimes B \ X \otimes C = [Min\ \{\underline{B}\,\underline{C}, \overline{B}\,\overline{C}, \overline{B}\,\underline{C}, \underline{B}\,\overline{C}\}, Max\ \{\underline{B}\,\underline{C}, \overline{B}\,\overline{C}, \overline{B}\,\underline{C}, \underline{B}\,\overline{C}\}] \tag{10}$$

$$\frac{\otimes B}{\otimes C} = \otimes B \ X \otimes C^{-1} = \left[Min\left\{\frac{\underline{B}}{\underline{C}}, \frac{\underline{B}}{\overline{C}}, \frac{\overline{B}}{\underline{C}}, \frac{\overline{B}}{\overline{C}}\right\}, Max\left\{\frac{\underline{B}}{\underline{C}}, \frac{\underline{B}}{\overline{C}}, \frac{\overline{B}}{\underline{C}}, \frac{\overline{B}}{\overline{C}}\right\}\right] \tag{11}$$

$$L(\otimes B) = \overline{B} - \underline{B} \tag{12}$$

The length of the grey $\otimes B = [\underline{B}, \overline{B}]$ was calculated from Equation (12).

If $\otimes B = [\underline{B}, \overline{B}]$ *and* $\otimes C\ [\underline{C}, \overline{C}]$ represent two grey numbers, the degree of greyness between these two numbers is obtained using Equation (13) (Bakar *et al.*, 2019). For this study, we used the grey linguistic variables based on grey numbers to check the impact of alternatives presented in Table 5.5.

$$P\ \{\otimes B \le \otimes C\} = \frac{Max\ \{0, L^* - Max\,(0, \overline{B} - \underline{C})\}}{L^*}$$

Where $L^* = L(\otimes B) + L(\otimes C)$ (13)

Table 5.5**.** The intensity of importance in linguistic variables adapted from the fundamental AHP scale of 1-9.

Number	**Linguistic Variables**	**Equivalent Grey numbers**	**Gas flaring reduction target (%)**	**Description**	**Benefit**
1	Full implementation of gas flaring policies and regulatory framework criteria	(6,9)	100% reduction-Zero Routine Flaring (ZRF)	If CO_2 emissions are decreased by 100%, and a 100% reduction in gas flaring	Limit temperature to below 1.5 °C warming Target
2	Significant implementation of gas flaring policies and regulatory framework criteria	(3,5)	90% Reduction	If CO_2 emissions are decreased by 45%, and a 90% reduction in gas flaring	Limit temperature to 1.5 °C warming Target
3	Partial implementation of gas flaring policies and regulatory framework criteria	(1,3)	50% Reduction	If CO_2 emissions are decreased by 25% and a 50% reduction in gas flaring	Temperature rises to 2 °C warming Target
4	BAU, maintaining the current status quo or Doing nothing	(0,1)	5% Reduction	Business as Usual (BAU) or maintain the current status quo with a 5.8% reduction in CO_2	Temperature rises to 2.7 °C warming Target

Implementation of flaring policies and regulatory framework main criteria and sub-criteria with the equivalent grey numbers (Full = [6-9], Significant = [3-5], Partial = [1-3], BAU = [0-1].

5.3.3. Grey Group TOPSIS (G-TOPSIS) Method

In 1981, Yoon and Hwang developed the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method (Yoon and Hwang, 2007). The Grey TOPSIS method assesses *n* alternatives using *m* parameters. The method determines the optimal positive and negative solutions within several alternatives. The least distance from the optimal positive solution and the highest distance from the optimal negative solution is referred to as an optimal alternative. Following Zare et al.'s (2018) recommendation, we established the following stages of the G-TOPSIS method.

Stage 1: First, we calculated the weights of each criterion based on expert opinion by using grey linguistic variables in Table 5.5. Assuming that the number of decision-makers is *k,* we can calculate the weight of criterion *j* weight of alternatives by using Equation 14.

$$\otimes wj = \frac{1}{k}\left[\otimes w_j^{\,1} + \otimes w_j^{\,2} + \ldots + \otimes w_j^{\,k}\right] \tag{14}$$

Stage 2: The linguistic variables were utilised to assess the significance of each research alternative in the criteria. Assuming that the number of decision-makers is *k* in criterion *j*, then the value of alternative *i* was calculated as follows (Equation 15):

$$\otimes G_{ij} = \frac{1}{k}\left[\otimes G_{ij}^{\,1} + \otimes G_{ij}^{\,2} + \ldots + \otimes G^{k}{}_{ij}\right] \tag{15}$$

Stage 3: The grey decision matrix was denoted as follows in Equation 16:

$$D = \begin{bmatrix} \otimes G_{11} & \otimes G_{12} & \ldots & \otimes G_{1n} \\ \otimes G_{21} & \otimes G_{22} & \ldots & \otimes G_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ \otimes G_{m1} & \otimes G_{m2} & \ldots & \otimes G_{mn} \end{bmatrix} \tag{16}$$

where $\otimes G_{ij}$ represents the significance of alternative *i* in criterion *j.*

In Stage 4, we represented a standardised matrix of grey decisions, as shown in Equation 17:

$$D^* = \begin{bmatrix} \otimes G_{11}^{\;*} & \otimes G_{12}^{\;*} & \dots & \otimes G_{1n}^{\;*} \\ \otimes G_{21}^{\;*} & \otimes G_{22}^{\;*} & \dots & \otimes G_{2n}^{\;*} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ \otimes G_{m1}^{\;*} & \otimes G_{m2}^{\;*} & \dots & \otimes G_{mn}^{\;*} \end{bmatrix} \tag{17}$$

Where the criteria were benefit attributes such as the temperature limit where a low warming target is beneficial, then Equation 18 was utilised for normalisation:

$$G^*_{ij} = \left[\frac{\underline{G}_{ij}}{G_j^{\max}}, \frac{\overline{G}_{ij}}{G_j^{\max}} \right] \quad where\ G_j^{\max} = \max_{1 \le j \le m} \left\{ \overline{G}_{ij} \right\} \tag{18}$$

Also, where the cost attributes were based on reduction targets for CO_2 and gas flaring and high percentage reductions were beneficial, Equation 19 was utilised for normalisation purposes.

$$G^*_{ij} = \left[\frac{\underline{G}_j^{\min}}{G_j^{\min}}, \frac{G_{ij}^{\min}}{G_j^{\min}} \right] \quad where\ G_j^{\min} = \min_{1 \le j \le m} \left\{ \overline{G}_{ij} \right\} \tag{19}$$

In Stage 5, we developed a grey-weighted normalised decision matrix as shown in Equation 20:

$$V = \begin{bmatrix} \otimes V_{11} & \otimes V_{12} & \dots & \otimes V_{1n} \\ \otimes V_{21} & \otimes V_{22} & \dots & \otimes V_{2n} \\ . & . & . & . \\ . & . & . & . \\ . & . & . & . \\ \otimes V_{m1} & \otimes V_{m2} & \dots & \otimes V_{mn} \end{bmatrix} \quad Where\ \otimes V_{ij} = \otimes G^*_{ij} \ \mathrm{X} \otimes w_j \tag{20}$$

Stage 6: The optimal positive and negative solutions were calculated respectively using Equations 21 and 22:

$$S^{\max} = \left\{ \left[\max_{1 \le j \le m} \underline{V}_{i1}, \max_{1 \le j \le m} \overline{V}_{i1} \right], \left[\max_{1 \le j \le m} \underline{V}_{i2}, \max_{1 \le j \le m} \overline{V}_{i2} \right], \dots, \left[\max_{1 \le j \le m} \underline{V}_{in}, \max_{1 \le j \le m} \overline{V}_{in} \right] \right\} \tag{21}$$

$$S^{\min} = \left\{ \left[\min_{1 \le j \le m} \underline{V}_{i1}, \min_{1 \le j \le m} \overline{V}_{i1} \right], \left[\min_{1 \le j \le m} \underline{V}_{i2}, \min_{1 \le j \le m} \overline{V}_{i2} \right], \dots, \left[\min_{1 \le j \le m} \underline{V}_{in}, \min_{1 \le j \le m} \overline{V}_{in} \right] \right\} \tag{22}$$

Stage 7: The potential greyness degree between optimal positive and negative alternatives was calculated using Equation 23:

$$P\left\{ S_i \le S^{\max} \right\} = \frac{1}{n} \sum_{j=1}^{n} P \left\{ \otimes V_{ij} \le \otimes G_j^{\max} \right\} \tag{23}$$

Stage 8: Alternatives were arranged in descending order corresponding to the values obtained in Stage 7. Higher priority was given to the alternative with the highest greyness degree.

5.4. Results

5.4.1. Results of AHP Gas Flaring Policies and Regulatory Framework Main Criteria

The overall weight and ranking of the main criteria and sub-criteria from group A and B respondents are shown in Tables 5.6 and 5.7. The estimated weights of the seven main criteria (parent level) are shown in Figure 5.3.

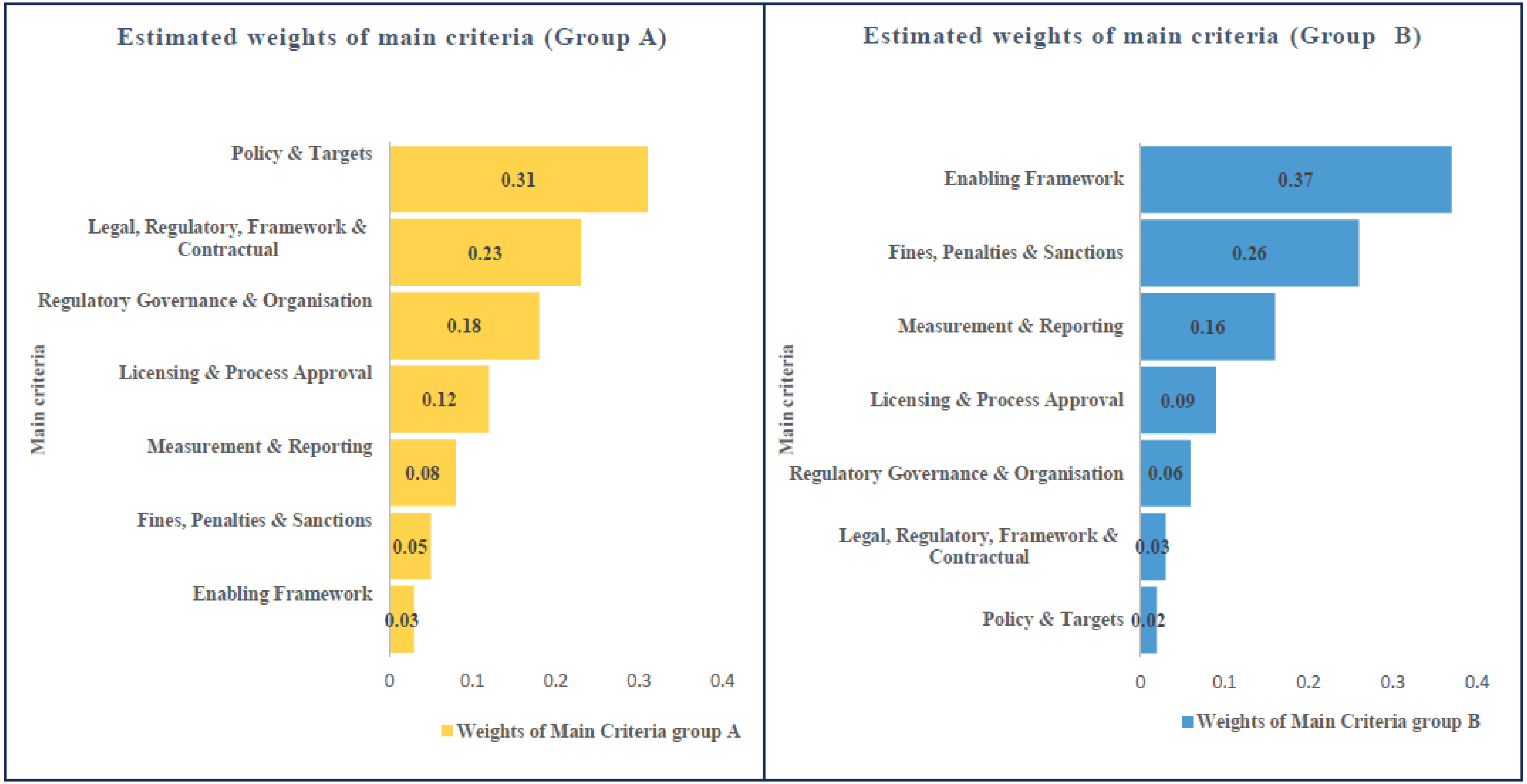

Figure 5.3**.** Estimated weights of the seven main criteria from groups A and B respondents.

‘‘Policy and targets’’ and ‘‘enabling framework’’ criteria were estimated as having the highest importance, with a weight of 0.31 for group A and 0.37 for group B. Although some respondents in both groups also estimated ‘‘policy and targets’’ and ‘‘enabling framework’’ as low, with a weight of 0.02 for group A and 0.03 for group B, overall, results indicate that these were estimated as of the highest importance among the main criteria in both groups. The remaining main criteria were ranked as follows: ‘‘legal, regulatory framework and contractual rights’’ (group A=0.23, group B=0.16); ‘‘regulatory governance and organisation’’ (group A=0.18, group B=0.06); ‘‘licensing and process approval’’ (group A=0.12, group B=0.09); ‘‘measurement and reporting’’ (group A=0.08, group B=0.16); and ‘‘fines, penalties and sanctions’’ (group A=0.03, group B=0.37). Results from the calculation of the weights of each criterion are presented in Tables 5.6, 5.7, Fig. 5.3, and Appendix A1 & A2.

5.4.2. Results of AHP Local Priority Weights of Gas Flaring Policies and Regulatory Framework Sub-Criteria

Appendix A3 - A16 presents the pairwise comparison matrix for each sub-criterion. Fig. 5.4 displays the local priority weight of the sub-criteria for both groups of respondents.

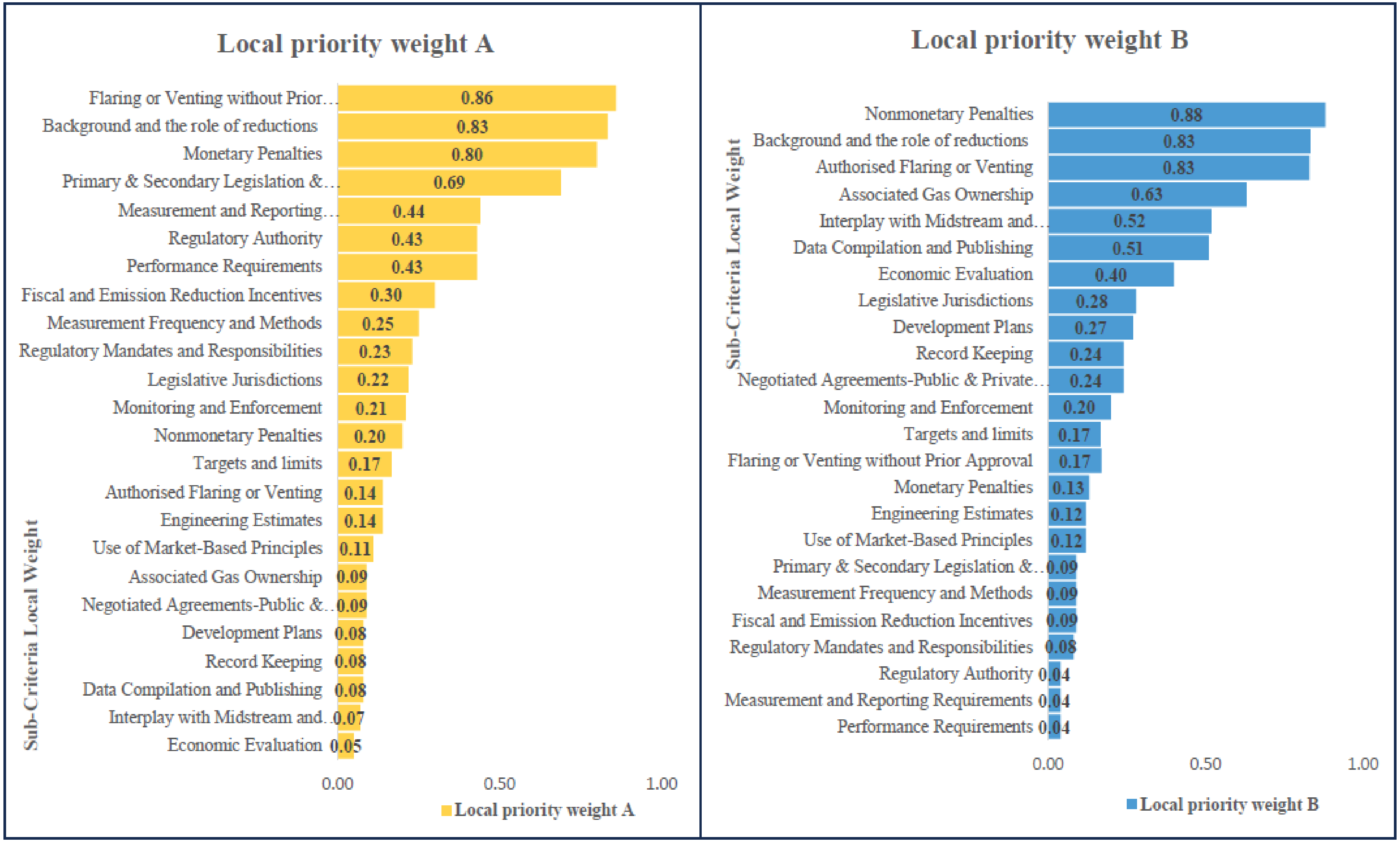

Figure 5.4. Local weights of sub-criteria (Group A and B stakeholders).

Sub-criteria within policy and targets, including background and the role of reductions in meeting environmental and economic objectives, and targets and limits are ranked as 0.83 and 0.17 each in both stakeholder groups. For the main criteria of legal, regulatory, framework and contractual rights, group A prioritised legislative jurisdictions as 0.22 and associated gas ownership as 0.09, while Group B ranked them as 0.28 and 0.63, respectively. Sub-criteria within the regulatory governance and organisation main criterion ranked regulatory authority as A=0.43, B=0.04, regulatory mandates and responsibilities as A=0.23, B=0.08, monitoring and enforcement as A=0.21, B=0.20, development plans as A=0.08, B=0.27, and economic evaluation as A=0.05, B=0.40). Sub-criteria within licensing and process approval ranked the various sub-criteria as follows: flaring or venting without prior approval (A=0.86, B=0.17) and authorised flaring or venting (A=0.14, B=0.83). Similarly, sub-criteria within measurement and reporting were ranked as: measurement and reporting requirements (A=0.44, B=0.04), measurement frequency and methods (A=0.44, B=0.09), engineering estimates (A=0.14, B=0.12), record keeping (A=0.08, B=0.24), and data compilation and publishing (A=0.08, B=0.51). The analytical findings in Fig. 4 show that sub-criteria within the main criterion of fines, penalties, and sanctions were ranked as monetary penalties (A=0.80, B=0.13) and nonmonetary penalties (A=0.20, B=0.88). Finally, the enabling framework sub-criteria were ranked as: performance requirements (A=0.43, B=0.04), fiscal and emission reduction incentives (A=0.30, B=0.09), use of market-based principles (A=0.11, B=0.12), negotiated agreements between the public and the private sector (A=0.09, B=0.24), interplay with midstream and downstream regulatory framework (A=0.07, B=0.52).

From Fig. 5.4, it is evident that the flaring or venting without prior approval (group A=0.86) and nonmonetary penalties (group B=0.88) in the 'Licensing and process approval', and 'Fines, penalties and sanctions' components were the most significant sub-criteria. These were followed by background and the role of reductions in meeting environmental and economic objectives (group A and B=0.83 each) in the 'Policy and targets' criteria. 'Monetary penalties' (group A=0.80) in the 'Fines, penalties and sanctions' main criterion and authorised flaring or venting (group A=0.83) in the 'Licensing and process approval' main criterion were also ranked high by both groups. Primary and secondary legislation and regulation (group A=0.69) and associated gas ownership (group B=0.63) in the 'legal, regulatory, framework and contractual rights' main criterion were also described as significant, followed by measurement and reporting requirements (group A=0.44) and interplay with midstream and downstream regulatory framework (group A=0.52) in the 'Measurement and reporting and Enabling framework' main criteria. Consistency ratio (CR) values were well within the appropriate range for the matrices presented in Tables 5.5 and 5.6, which guarantees the efficiency of the decision-maker.

5.4.3. Overall Global Weights Ranking of Sub-Criteria

Tables 5.6 (Group A stakeholders), 5.7 (Group B stakeholders), and Figure 5.5 shows the final global weighting of the sub-criteria.

Table 5.6**.** The overall weight and ranking of main criteria and sub-criteria (Group A Stakeholders).

Main Criteria	Weights of Main Criteria	Main Criteria Ranking	Main Criteria CR	Sub-Criteria	Sub-Criteria CR	Local priority weight	Local Rank	Global priority weight	Overall Rank
Policy and Targets	0.31	1	9.7%	Background and the Role of Reductions	0.0%	0.83	1	0.26	1st
				Targets and limits	0.0%	0.17	2	0.053	5th
Legal, Regulatory, Framework and Contractual	0.23	2	9.7%	Primary & Secondary Legislation & Regulation	5.6%	0.69	1	0.159	2nd
				Legislative Jurisdictions	5.6%	0.22	2	0.051	6th
Regulatory Governance and Organisation	0.18	3	9.7%	Associated Gas Ownership	5.6%	0.09	3	0.021	12th
				Regulatory Authority	9.0%	0.43	1	0.077	4th
Licensing and Process Approval	0.12	4	9.7%	Regulatory Mandates and Responsibilities	9.0%	0.23	2	0.041	7th
				Monitoring and Enforcement	9.0%	0.21	3	0.038	9th
Measurement and Reporting	0.08	5	9.7%	Development Plans	9.0%	0.08	4	0.038	10th
				Economic Evaluation	9.0%	0.05	5	0.009	18th
Fines, Penalties and Sanctions	0.05	6	9.7%	Flaring or Venting without Prior Approval	0.0%	0.86	1	0.103	3rd
				Authorised Flaring or Venting	0.0%	0.14	2	0.017	14th

Enabling Framework	0.03	7	9.7%	Measurement and Reporting Requirements	6.3%	0.44	1	0.035	11th
				Measurement Frequency and Methods	6.3%	0.25	2	0.02	13th
				Engineering Estimates	6.3%	0.14	3	0.011	16th
				Record Keeping	6.3%	0.08	4	0.006	20th
				Data Compilation and Publishing	6.3%	0.08	5	0.006	21st
				Monetary Penalties	0.0%	0.8	1	0.04	8th
				Nonmonetary Penalties	0.0%	0.2	2	0.01	17th
				Performance Requirements	8.20%	0.43	1	0.013	15th
				Fiscal and Emission Reduction Incentives	8.20%	0.3	2	0.009	19th
				Use of Market-Based Principles	8.20%	0.11	3	0.003	22nd
				Negotiated Agreements-Public & Private Sector	8.20%	0.09	4	0.003	23rd
				Interplay with Midstream and Downstream RF	8.20%	0.07	5	0.002	24th

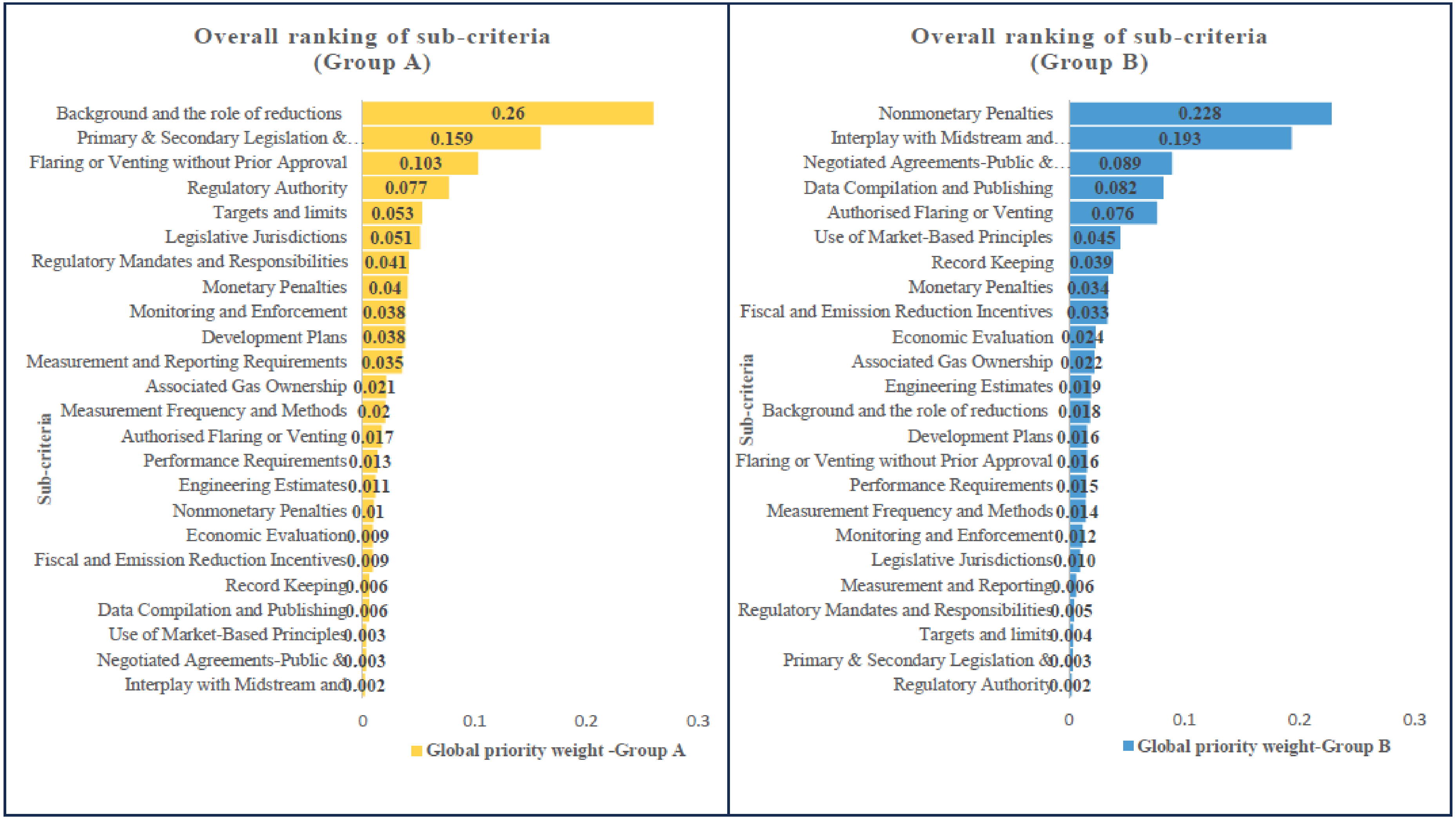

Figure 5.5**.** Overall global ranking of sub-criteria (Group A & B).

Fig. 5.5 shows the final overall ranking results of the sub-criteria after calculating global weights. From Table 5.6 and Figure 5.5, it is evident that background and the role of reductions in meeting environmental and economic objectives obtained the highest priority global weight of 0.26 among all sub-criteria, followed by primary and secondary legislation and regulation with a global priority weight of 0.159. The third and fourth positions among all sub-criteria have respective global priority weights of 0.103 and 0.077 for group A stakeholders.

Group B stakeholders' global ranking of gas flaring policies and regulatory framework sub-criteria is shown in Table 5.7 and Figure 5.5, from which it is evident that Nonmonetary Penalties and Interplay with Midstream and Downstream regulatory frameworks were given the highest priority global weight of 0.228 and 0.193, respectively.

Table 5.7**.** The overall weight and ranking of main criteria and sub-criteria (Group B Stakeholders).

Main Criteria	Weights of Main Criteria	Main Criteria Ranking	Main Criteria CR	Sub-Criteria	Sub-Criteria CR	Local priority weight	Local Ranking	Global priority weight	Overall Ranking
Enabling Framework	0.37	1	9.6%	Nonmonetary Penalties	0.0%	0.88	1	0.228	1st
Fines, Penalties and Sanctions	0.26	2	9.6%	Interplay with Midstream and Downstream RF	9.8%	0.52	5	0.193	2nd
Measurement and Reporting	0.16	3	9.6%	Negotiated Agreements-Public & Private Sector	9.8%	0.24	11	0.089	3rd
Licensing and Process Approval	0.09	4	9.6%	Data Compilation and Publishing	9.3%	0.51	6	0.082	4th
Regulatory Governance and Organisation	0.06	5	9.6%	Authorised Flaring or Venting	0.0%	0.83	3	0.076	5th
Legal, Regulatory, Framework and Contractual	0.03	6	9.6%	Use of Market-Based Principles	9.8%	0.12	17	0.045	6th
Policy and Targets	0.02	7	9.6%	Record Keeping	9.3%	0.24	10	0.039	7th
				Monetary Penalties	0.0%	0.13	15	0.034	8th
				Fiscal and Emission Reduction Incentives	9.8%	0.09	20	0.033	9th
				Economic Evaluation	9.6%	0.40	7	0.024	10th
				Associated Gas Ownership	8.9%	0.63	4	0.022	11th
				Engineering Estimates	9.3%	0.12	16	0.019	12th
				Background and the Role of Reductions	0.0%	0.83	2	0.018	13th
				Development Plans	9.6%	0.27	9	0.016	14th
				Flaring or Venting without Prior Approval	0.0%	0.17	14	0.016	15th
				Performance Requirements	9.8%	0.04	24	0.015	16th

	Measurement Frequency and Methods	9.3%	0.09	19	0.014	17th
	Monitoring and Enforcement	9.6%	0.20	12	0.012	18th
	Legislative Jurisdictions	8.9%	0.28	8	0.010	19th
	Measurement and Reporting Requirements	9.3%	0.04	23	0.006	20th
	Regulatory Mandates and Responsibilities	9.6%	0.08	21	0.005	21st
	Targets and limits	0.0%	0.17	13	0.004	22nd
	Primary & Secondary Legislation & Regulation	8.9%	0.09	18	0.003	23rd
	Regulatory Authority	9.6%	0.04	22	0.002	24th

5.4.4. G-TOPSIS Analysis for Policy Development on Gas Flaring

The findings of the G-TOPSIS analysis (Table 5.8) show that alternative A1 (full implementation of gas flaring policies and regulatory framework criteria) with a weight of 1 is the best solution. This requires CO_2 emissions to decrease by 100%, and a corresponding reduction in gas flaring to limit temperature rises below the 1.5 °C warming target. The second-best alternative is A2 (significant implementation of gas flaring policies and regulatory framework criteria), with a weight of 0.60715. This requires CO_2 emissions to decrease by 45% and a corresponding 90% reduction in gas flaring to limit temperature to a 1.5 °C warming target. The partial implementation of gas flaring policies and regulatory framework criteria (A3), which require CO_2 emissions to decrease by 25% and a 50% reduction in gas flaring translating to a temperature rise to a 2 °C warming target, is third, with a weight of 0.34740. The business as usual (BAU), which maintains the status quo and the current CO_2 and flaring reduction trajectories of 5.8% and 5%, respectively, is the least important alternative with a weight of 0. Table 5.8 shows the results of the positive grey ideal solution and negative ideal solution based on the G-TOPSIS analysis.

Table 5.8. G-TOPSIS final ranking for available alternatives of gas flaring policies and regulatory framework

Code	**Alternative**	S_i^+	S_i^-	P_i	**Rank**
A1	Full implementation of gas flaring policies and regulatory framework main criteria	0	0.30767	1	1
A2	Significant implementation of gas flaring policies and regulatory framework main criteria	0.13532	0.20914	0.60715	2
A3	Partial implementation of gas flaring policies and regulatory framework main criteria	0.21028	0.11194	0.34740	3
A4	Business As Usual (BAU) or do nothing	0.30767	0	0	4

The greyness degree between ideal solutions and alternatives, including the ideal solutions and alternatives, was measured as shown below:

$P_1\ (S_1 \leq S^{max}) = 1$

$P_2\ (S_2 \leq S^{max}) = 0.60715$

$P_3\ (S_3 \leq S^{max}) = 0.34740$

$P_4\ (S_4 \leq S^{max}) = 0$

The ranking of alternatives is based on the feasible degree of greyness values presented below:

$P_1 > P_2 > P_3 > P_4$

5.5. Discussion

To abate gas flaring on a global scale requires the implementation of collaborative and consistent national and international policies and regulatory frameworks. The ranking of the main criteria used in this study has recognised policy and targets (with weights of 0.31 for group A stakeholders and 0.02 for group B stakeholders) and an enabling framework (with weights of 0.37 for group A stakeholders and 0.03 for group B stakeholders) as the most important elements in reducing global gas flaring. Gas flaring and venting abatement policies and targets are set to avoid resource wastage and reduce local air pollution and GHG emissions, while an enabling framework includes a range of economic instruments or flaring abatement programmes that can be introduced to encourage producers and specifically target gas flaring (e.g., fiscal, or market-based incentives).

A lack of appropriate policies and targets in gas flaring remains a key challenge in global flaring reduction, particularly where oil and gas companies' political lobbying limits effective domestic implementation (Loe and Ladehaug, 2012). Although several studies (e.g., Loe and Ladehaug, 2012; Soltanieh et al., 2016; Karasalihović Sedlar et al., 2018; Ialongo et al., 2021; Rodrigues, 2022; Shahab-Deljoo et al., 2023; Wen, Xiao and Peng, 2023) have also identified these criteria as some of the barriers to achieving global flaring reduction, our study's ranking underscores the urgent need for a more extensive global initiative to prioritise the implementation of these top two criteria. While our study highlights the urgent need for a more comprehensive global effort to implement these top two criteria, the entire ranking can serve as a global benchmark for policymakers and gas flaring nations to consider in setting future targets.

Economic benefits, commonly prioritised by oil and gas-rich nations over climate change concerns, are the main barriers to functional policy implementation (Korppoo, 2018; Ylä-Anttila et al., 2018). Various studies (including those by Svensson, 2005; Castelo Branco, Szklo and Schaeffer, 2010; Loe and Ladehaug, 2012; Buzcu-Guven and Harriss, 2014; Olusegun Fawole, Cai and Mackenzie, 2016; Korppoo, 2018; Mrabure and Ohimor, 2020; Olujobi and Olusola-Olujobi, 2020; Zhizhin et al., 2021; Rodrigues, 2022; Bello, 2023; Shahab-Deljoo et al., 2023; Wen, Xiao and Peng, 2023) have identified the need for an enabling framework including fiscal incentives and emission reduction incentives for investments and a weak natural gas market and tax reductions to reduce flaring. However, the extent to which this criterion hinders flaring reduction globally has not been sufficiently researched. Accordingly, results from group B stakeholders ranked the ‘‘enabling flaring framework’’ criteria as one of the essential ways to reduce flaring globally. While some gas-flaring nations have passed flare abatement laws and instituted fiscal incentives, these country-specific laws and measures have not yielded the desired outcome due to a lack of political will to end gas flaring and provide economically viable gas markets through operational policies and regulations (Akinola and Wissink, 2018; Iornumbe, 2019; Benson, 2020; Olujobi, 2020). This includes the fossil fuel industry, its influence over policy, and the overall economic benefits objective of oil companies and oil-rich nations. Gas flaring regulations vary globally, making it challenging for oil companies to follow all applicable laws. This inconsistency can result in some companies flaring gas in countries with weaker regulations. As this research proposes uniform global policies and regulations to mitigate global gas flaring, it would ensure a fairer playing field, simplify compliance, reduce ambiguity, and lower the cost of reducing gas flaring through a standardised approach.

For Group A stakeholders, legal and regulatory frameworks and contractual rights hold a weight of 0.23, while Group B's have a weight of 0.03. These frameworks are typically anchored in national or local legislation that governs the industry and environmental management at the national or local level. Sanctions and penalties for non-compliance with gas flaring regulations are also important considerations. Regarding fines, penalties and sanctions, a weight of 0.26 was assigned by Group A stakeholders, while Group B stakeholders assigned a weight of 0.05. In most jurisdictions, legislation and contractual provisions impose fines, penalties, sanctions, mandatory payments, or other enforcement mechanisms for noncompliance with gas flaring regulations. However, regulatory failures in designing and implementing gas-flaring policies and ineffective penalty systems lead to inconsistencies. Such inconsistency is largely attributed to ambiguous and incoherent legislative and regulatory frameworks, non-transparent reporting, and poor disclosure of gas-flaring statistical data. These factors are also linked with the fundamental reasons why investment in associated gas recovery and processing facilities may be lacking. Addressing these criteria and sub-criteria should form an integral part of the global approach to deterring flaring offenders and achieving the Zero Routine Flaring by 2030 goal. Based on the rankings from the two groups of stakeholders, it is crucial to have effective and comprehensive policies and targets for reducing gas flaring to achieve the overall environmental and economic goals. While it is crucial to have measures within the legal and regulatory frameworks and contractual rights, rather than relying exclusively on fines, penalties, and sanctions, these measures are still not as important as having strong and transparent gas flaring policies and targets that create an enabling framework.

The regulatory governance and organisation criteria determine which institutions have the authority to regulate the oil and gas industry. Adequate and effective measurement and reporting are also crucial criteria, with national or local regulations mandating companies to record, process, and submit the information specified by the regulator. However, our analysis reveals that current administrative frameworks may not be suitable for implementing current legal and regulatory provisions and new policies independently and promptly. As a result, Group A stakeholders have a weight of 0.18 in the regulatory governance and organisation criterion, while Group B stakeholders have a weight of 0.06. Similarly, measurement and reporting have a weight of 0.16 for Group A stakeholders and 0.08 for Group B stakeholders. These rankings further indicate regulatory failure in designing and implementing gas flaring policies, an incoherent legislative and regulatory framework, a lack of monitoring and enforcement capacity, and non-transparent reporting of gas flaring data in most jurisdictions. Furthermore, although strengthening institutions involved in flaring management is essential, the two stakeholder groups have ranked these criteria as third in importance, considering implementing appropriate policies and targets and establishing a suitable enabling framework to be more significant in achieving flaring reduction targets. Although the regulatory governance and organisation and measurement and reporting criteria are essential to the overall goal, results show that they are not as crucial as having strong and transparent policies and targets, an enabling framework that supports these goals, and legal and regulatory frameworks that protect contractual rights.

Group A and B stakeholders ranked licensing and process approval as the least important criteria, with weights of 0.12 and 0.09, respectively. Despite being ranked the least important criterion, it is crucial to achieving the overall global flaring reduction. Few studies have identified this criterion as a barrier to meeting the ZRF target. However, gas flaring and venting regulations depend on how the associated gas is treated, the oil development rights granted in primary legislation, and the application and approval procedures for gas flaring and venting. The right to flare and vent can be obtained through a flaring and venting permit, the field development plan for a license or contract, and an environmental license. Based on these factors, this criterion may not be as significant as the others. While it is worth addressing, it may have less impact on the overall decision-making process in gas flaring policies and regulatory frameworks to abate flaring.

In situations where decision-making is uncertain, G-TOPSIS can enhance decision-making precision. Despite slow rates of global CO_2 and gas flaring reductions, the G-TOPSIS analysis revealed relatively optimistic scenarios, identifying four critical conceptual pathways representing different interpretations and consequences. Depending on the chosen pathway, all scenarios must implement the AHP results as a foundational benchmark at different levels.

The best solution identified was Alternative A1, which has a weight of 1 and requires full implementation of the AHP results to stay on course and ensure that emission reduction goals are achieved. This suggests that all the criteria must be implemented, with particular emphasis on those that are ranked highly. Additionally, it requires CO_2 emissions to decrease by 100% and a corresponding decrease in gas flaring to limit temperature to below the 1.5 °C warming target. As global warming is likely to reach 1.5°C between 2030 and 2052 if emissions continue to increase at the current rate, the alternative A1 option would be the appropriate target to avoid long-term changes in the climate system. While the global warming rate is projected to exceed 1.5°C, countries' pledges to reduce emissions are currently not on track to limit global warming to 1.5°C. This implies that climate-related risks to health, livelihoods, and other risks will increase (IPCC, 2018). Though the alternative A1 conceptual framework advocates stabilising global temperature to just below 1.5°C, it is crucial to take action to limit global warming to avoid the consequences of climate-related risks.

The most viable alternative to reduce greenhouse gas emissions is A2, which emphasises the significant implementation of gas flaring policies and regulatory frameworks. A2 has a weight of 0.60715 and aims to decrease global net anthropogenic CO_2 emissions by 45% from 2010 levels by 2030. Additionally, it involves a 90% reduction in all non-emergency gas flaring to limit temperature rises to 1.5 °C. Alternative A2 appears more feasible considering the current carbon lock-in conditions in industrial nations (e.g., Unruh, 2000; Mattauch, Creutzig and Edenhofer, 2015; Mac Kinnon, Brouwer and Samuelsen, 2018; Ylä-Anttila et al., 2018; Janipour et al., 2020). This approach is compatible with IPCC projections and in line with stabilising global temperature rise at 1.5°C. However, achieving this goal will require significant reductions in emissions of methane and black carbon by 35% or more of both by 2050 relative to 2010 (IPCC, 2018). Additionally, as the choice of the measure of global temperature affects the estimated remaining carbon budget, limiting the total cumulative global anthropogenic emissions of CO_2 since the pre-industrial period is crucial. Anthropogenic CO_2 emissions since the pre-industrial period have depleted the remaining budget by 2200 ± 320 $GtCO_2$. Current emissions of 42 ± 3 $GtCO_2$ per year since 2017 underscore the urgency of implementing this alternative.

The third alternative (A3), weighing 0.3474, is the partial implementation of gas flaring policies and regulatory framework criteria, which aim to reduce CO_2 emissions by 25% and gas flaring by 50%, resulting in a 2°C or below warming target. This conceptual pathway also requires significant CO_2 emissions and gas flaring reductions like those in pathways limiting warming to 1.5°C. While the 2018 IPCC report acknowledges the possibility of temporary global temperature exceedance of 1.5°C, this projected scenario would significantly increase the risk of irreversible climate impacts such as the collapse of polar ice shelves and accelerated sea level rise. Limiting warming to 1.5°C or below, rather than to 2°C, can help reduce these risks, but the specific greenhouse gas emissions pathway adopted will determine the impacts the world will experience.

An inimical option for dealing with global gas flaring and climate change is to adhere to the current status quo, known as business-as-usual (BAU). This implies keeping the current levels of CO_2 and flaring reduction trajectories (as projected by IEA, GGFR/The World Bank) at 5.8% and 5%, respectively (IEA, 2021, 2022; GGFR/The World Bank, 2023). This option is the least favourable with a weight of 0, as it would result in an annual increase in energy-related and industrial process CO_2 emissions from 34 Gt in 2020 to 36 Gt in 2030, with no significant reduction after that, remaining around this level until 2050. This trajectory, if continued, would lead to a projected 2.7°C rise in global average surface temperature by 2100, along with a similar increase in non-energy related GHG emissions (IEA 2021). To avoid this, it is crucial that the stated policies scenario (STEPS) and announced pledges case (APC) are fully implemented and achieved on time, regardless of whether current country-specific policies support them.

While the presented scenarios are consistent with previous projections, the findings provide additional insight into the required global policies and regulatory framework for achieving ZRF and supporting the various scenarios. The most effective solution for global gas flaring and CO_2 emissions is alternative A1. However, there is no easy solution to the problem of global gas flaring and climate change. The novelty of this research lies in the findings indicating that alternative A2 is the most feasible option for reducing gas flaring and CO_2 emissions, implying that significant progress can be achieved without completely overhauling the economy. Nevertheless, this alternative still requires significant reductions in global gas flaring and CO_2 emissions, and its political feasibility remains uncertain. Alternative A4, which entails maintaining the current status quo, is the least favourable option for addressing global gas flaring and climate change. If this trajectory continues, the global average surface temperature is projected to rise by 2.7 °C by 2100.

5.6. Conclusions and Policy Implications

This study aimed to evaluate stakeholder preferences for different policies and regulatory options, determining the most optimised and effective to help eliminate routine gas-flaring by 2030 and achieve net zero emissions by 2050 whilst addressing good governance, justice, and fair implementation. By understanding these criteria, sub-criteria, and the available alternatives, industry, environmental policymakers, and the IOCs can plan better for and successfully implement and execute global gas flaring policies and regulatory frameworks.

Four conclusions are derived from the criteria-weights estimation and G-TOPSIS results. First, due to a consensus on the identified criteria and sub-criteria, as evidenced by the successive GGFR/World Bank consultations and multiple scholarly publications on the topic, and despite the differing opinions and rankings between the two stakeholder groups, A and B, all the identified gas flaring policies and regulatory framework criteria and sub-criteria were found to be crucial and integral to achieving the 2030 zero routine flaring target. Second, policy and targets and enabling frameworks were the most significant criteria, followed by legal, regulatory framework and contractual rights, fines, penalties, and sanctions; regulatory governance and organisation; measurement and reporting; and licensing and process approval. Third, the background and role of reductions in meeting environmental and economic objectives and nonmonetary penalties are the most crucial sub-criteria to abate global gas flaring. Fourth, based on G-TOPSIS results, alternative A1 (full implementation of gas flaring policies and regulatory framework criteria) is considered the most effective alternative to support a decrease in CO_2 by 80-100% and a corresponding reduction in gas flaring to limit temperature to meet the below 1.5 °C warming target. This is followed by alternative A2 (significant implementation of gas flaring policies and regulatory framework criteria) requiring CO_2 emissions to decrease by 45%, corresponding to a 90% reduction in gas flaring to limit temperature to a 1.5 °C warming target, and partial implementation of gas flaring policies and regulatory framework criteria (A3), which require CO_2 emissions to decrease by 25%, and a 50% reduction in gas flaring translating to temperature rise to 2 °C warming target. The business as usual (BAU) or do nothing alternative maintains the status quo and the current CO_2 and flaring reduction trajectories of 5.8% and 5%, respectively.

Finally, we argue that our findings illustrate the importance of policy coherence, consistency, and fairness in constructing transnational policies and regulatory frameworks for gas flaring reduction, accompanied by a reciprocal, legally binding set of policies and agreements between countries to avoid ineffective individual country-specific abatement efforts.

5.7. Limitations

While the criteria, sub-criteria and alternatives identified, prioritised, and selected in this study can serve as a global benchmark to abate gas flaring and CO_2 emissions, generalisations are limited by the non-random sample of respondents. Further testing of policy options through surveys sampling a larger demographically representative subset of the global population would be beneficial.

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Chapter 6

Synthesis and Conclusion

6.1. Introduction

The aim of this thesis was to integrate multilevel governance, policy coherence, good governance, and energy justice to analyse global gas flaring issues and optimise policy solutions and regulations to stimulate progress towards targets of zero routine flaring by 2030 and net zero emissions by 2050. It considered options that encompass fairness and equity while supporting the energy transition. This chapter provides a synthesis, highlighting each chapter's key findings and knowledge contributions towards achieving the overarching aim and specific research questions. It discusses the key emerging themes and implications for global gas flaring practices, highlights advances and policy relevance, implications for policies and practice, offers crucial policy recommendations, suggests potential avenues for future research, and provides an overall conclusion. This chapter also recommends how global gas flaring policy and practice can be improved through a whole system approach integrating multilevel governance, policies, good governance, and energy justice.

6.2. Key Findings and Knowledge Contributions to Global Gas Flaring Research

In Chapter one, I identified the research and conceptual gaps that hindered progress in reducing global gas flaring, guiding the focus of subsequent chapters. Chapter 1 also highlighted the key trends, including the environmental and health impacts of gas flaring and governance arrangements to reduce the impact. It presented the idea of natural gas as a temporary bridge fuel to support transitions to sustainability. The study's objectives, research questions, and approaches applied to achieve the results, including the framework and methodology used to investigate the research questions, were outlined. The case study approach and a mixed methods approach combining document analysis, semi-structured interviews, exit interviews, and expert surveys were established as necessary to gain insights into gas flaring issues on different scales.

Chapter two focused on a systems approach to global gas flaring issues and addressed objective 1, which aimed to reconceptualise and enhance theories linked to global gas flaring by proposing a new perspective on global gas flaring issues. As global gas flaring involves complex governance, policy, and has justice implications, requiring a holistic approach, this chapter suggested that a systems approach, with multiple points of entry for tackling the issues of global gas flaring, would be appropriate. The literature review established the theoretical and conceptual foundation for the rest of the thesis by examining how multilevel governance, policy coherence, good governance, and energy justice could benefit from a systems approach in the conceptualisation of global gas flaring. By analysing and connecting literature on MLG, policy coherence, good governance, and energy justice in a whole system framework, the chapter illustrated the utility of systems thinking and argued for a new approach to addressing global gas flaring issues. It established that an integrated approach to global gas flaring analysis offers the potential for better understanding of global gas flaring issues across scales and levels.

Based on Tables 2.1 and 2.2 and Figure 2.1 in Chapter 2, Figure 6.1 summarises the spatiality of the issues and injustices associated with global gas flaring across different scales and stages of the lifecycle. In this way, when natural gas is used to generate electricity, or for cooking or heating in Europe or Japan, local host communities in countries where oil and gas resources are being extracted and produced (such as Nigeria, Russia, Iraq, Iran and so on) inhale toxic compounds. Similarly, biomass burning and gas flares can also create the extreme West African aerosol plume, which perturbs the Hadley circulation and thereby changes Europe's winter climate (e.g., Booth et al., 2012). Such teleconnections are common in that climate patterns that span thousands of miles create links between weather phenomena at distant locations on Earth (Moser & Hart, 2015).

Moreover, these issues and injustices related to natural gas extraction and production, including gas flaring, are inherently contextual and can be experienced differently depending on location and time. In developed nations where there is access to information, functional regulations and good governance, environmental issues may be perceived as major and unjust, whereas in developing countries, the same issue may be viewed as a minor inconvenience. However, issues and injustices around global gas flaring do not vary depending on the person, place, and time. While previous studies highlight the importance of integrating a systems approach to address energy-related challenges (Laimon et al., 2022; McIntyre & Pradhan, 2003), this thesis has explored and emphasised the importance of effectively incorporating a system approach to address global gas flaring. These findings corroborate the ideas of Gagnon et al. (2002); Jenkins et al. (2014) and Martiskainen et al. (2021), who suggested that to advance environmental innovation and societal transition research, it is crucial to incorporate a comprehensive and intentional spatial whole systems approach that addresses issues of justice throughout the entire system. By adopting a whole systems justice approach, we can better understand the interrelated and intricate connections between various aspects of justice dynamics. Based on the findings from the literature, I posited that taking a whole system approach to understanding gas flaring may reveal the explicit connections within the global gas flaring system and prompt scholars to scrutinise the governance and justice dynamics of gas flaring and their relationships. Chapter two, thus, advanced theories of global gas flaring by operationalising the systems approach, proposing a new perspective that includes multilevel governance, policy coherence, good governance, and energy justice.

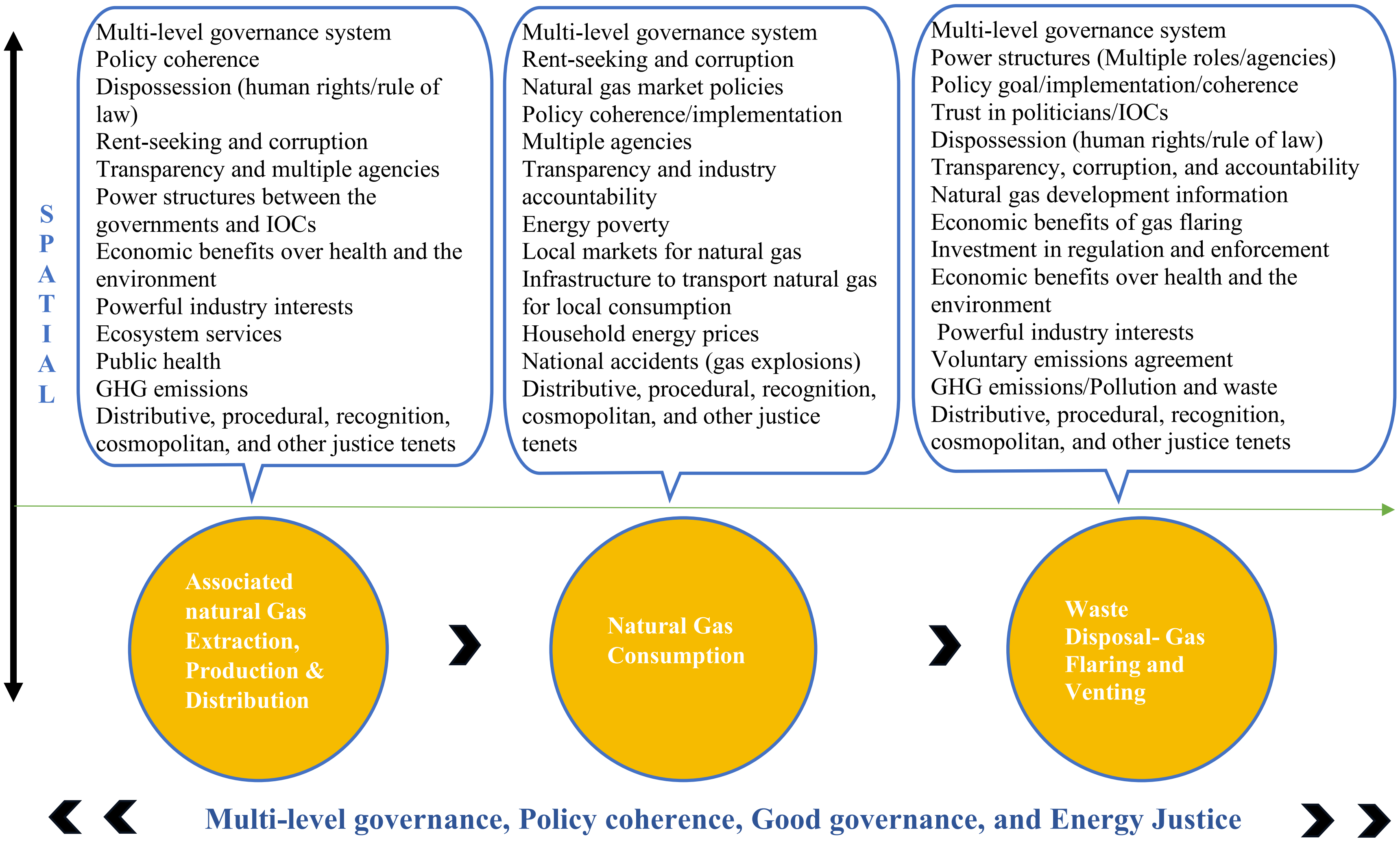

Figure 6.1. The spatiality of the systems thinking framework of global gas flaring impacts used in this thesis.

Throughout this thesis, semi-structured interviews, expert surveys, Q-methodology surveys, exit interviews, and AHP/G-TOPSIS surveys effectively revealed attitudes towards global gas flaring issues. Drawing on the accounts of different stakeholders interviewed and surveyed, I have advanced system thinking by incorporating multiple perspectives and stakeholders into the analyses. The thesis has developed a more comprehensive and nuanced understanding of complex gas flaring systems by considering the viewpoints of different groups and individuals, including policymakers. To the author's knowledge, such methods have not been employed together to investigate global gas flaring issues.

Another specific contribution is that the thesis created a new conceptual framework that challenges the current understanding of global gas flaring by combining theories and empirical data by utilising various analytical tools and techniques to identify patterns and relationships within complex global gas flaring systems. In particular, I used Qualitative Document Analysis (QDA) to undertake a horizontal-level policy coherence analysis of gas flaring in chapter 3, a Q-method approach to explore respondents' subjective attitudinal perspectives to establish conventional viewpoints around global gas flaring and energy justice issues in chapter 4, and the AHP and G-TOPSIS to evaluate preferences for various policies and regulatory options and determine the most optimised policies and regulations and practical approach to stimulate the elimination of routine gas flaring in chapter 5. This deep analysis enabled me to delve deeper into the underlying dynamics of the complex issues around global gas flaring systems and to identify strategies for developing more effective and sustainable solutions.

By combining these methods, the thesis addressed the need for mixed-methods research on global gas flaring. This research is significant as it seeks to understand how policy engagement and implementation work in a complex multilevel governance structure alongside contextual factors in the whole system approach. This research has highlighted the need for more studies that adopt a similar approach to expand our knowledge on this topic further. Overall, the thesis has advanced the system thinking approach by recognising and unpacking the interconnectedness of factors through empirically grounded research while also considering the broader context. As demonstrated, such an approach is essential to effectively achieve targets of zero routine flaring by 2030 and net zero emissions by 2050.

The interrelated and complex connections between natural gas and gas flaring dynamic systems approach were further elaborated in chapters 3 and 4, highlighting the importance of multilevel governance, policy coherence, good governance, and energy justice in solving global gas flaring issues. Chapter 3, objective 2 analysed Nigeria's multilevel governance system and assessed the policy coherence across gas flaring and energy sectors. The chapter identified the principal actors involved in gas flaring in Nigeria, examined the extent of gas flaring awareness and policy coherence across multiple sectors/policy domains, and evaluated the progress towards Nigeria's National Intended Contribution and national policy on climate change mitigation. Issues resulting from the political dynamics of personal rule and the lack of political will to implement gas flaring reduction policies, social marginalisation, equity, and rent-seeking issues in Nigeria's gas flaring system were found to pose a challenge. Additionally, there is a persistent lack of transparency, industry accountability and revenue accumulation by influential groups or individuals, which further raises questions concerning the political will to cap gas flaring. However, navigating the intricate political and institutional structures, policies, and socio-economic factors within a tightly controlled federal system and personal rule requires multilevel governance and policy coherence in addressing these national issues. The chapter showed the main actors involved in Nigeria's multilevel governance system pertaining to oil and gas governance operate under a fragmented Type II multilevel governance structure, with unclear leadership in the various authorities within a tightly controlled and top-down quasi-federal governance regime. The lack of political will to end gas flaring (Akinola & Wissink, 2018; Benson, 2020; Iornumbe, 2019; Olujobi, 2020) is also attributed to the Federal Government's and other stakeholders continued economic interest in fossil fuel extractivism.

Findings revealed that policy coherence around gas flaring (including efforts toward climate change mitigation), has been slowed by political partisanship, poor governance, lack of regulatory compliance, and policy conflict between environmental protection and economic development priorities. This supports other studies that have also found that Nigeria's federal government's strict political control over ministries, institutions, and parastatal agencies, has positioned the Niger Delta region as a sacrifice zone (De Souza, 2021; Ogwu, 2012; Unah & Iruoma, 2021), to meet both national policy objectives and personal or partisan policy objectives. As also argued by Hasan and Perot (2021), there is a persistent lack of transparency, industry accountability and revenue accumulation by influential groups or individuals. Findings thus underscore the urgent need for the inclusion of stakeholder voices across multiple sectors and scales of local/regional government, strengthening of federal institutions, a re-evaluation of economic aspirations through revenue diversification, and leadership that can temper the power of IOCs to exploit the complexity of the multilevel governance structure in Nigeria. The knowledge generated in chapter 3 will be of interest to global gas flaring researchers, oil and gas companies, policymakers, and gas flaring nations by helping the Nigerian government and governments of other flaring nations to improve environmental justice outcomes for flaring-affected communities.

These findings may help us to understand complex governance systems involving multiple levels or overlapping institutions and policies issues around gas flaring and its impact on local host communities (Dartey-Baah et al., 2014; Donwa et al., 2015; Husted & Blanchard, 2018; Idemudia et al., 2010; Ncala, 2016; Watts, 2004). Chapter 3 contributes to understanding policy coherence and divergence among sectors and institutional structures across supranational, federal, state, and local governments in governance systems involving multiple levels or overlapping institutions and policy issues. To improve good governance in Nigeria's gas flaring, it is crucial to implement significant changes. These changes should prioritise collaborative efforts among all stakeholders, including various levels of government, to meet the zero routine gas flaring target. To achieve this, greater accountability and transparency are crucial, as corruption and lack of industry accountability hinder effective governance and create a climate of dishonesty. The Transparency International rankings of 150 out of 180 Corruption Perceptions Index (CPI) (EITI, 2023) support the perception of a climate of dishonesty within the oil and gas industry. Analysing the issues and impact of gas flaring on different levels and scales revealed important complex interactions and processes. A multilevel approach enabled a better understanding and identification of the complex global factors influencing gas flaring, identifying and uncovering new perspectives that may have been overlooked in a single level of analysis, informing more effective future solutions.

Chapter 4 used insights from chapters 1, 2 and 3 to inform a Q-methodology study to analyse the emergent perspectives on energy justice and global gas flaring and evaluate how agreement and disagreement among these views contribute to developing equitable and inclusive gas flaring policies and regulations. Gas flaring concerns global externalities from associated greenhouse gas emissions, including local and global environmental injustice. However, the absence of a fair and equitable benefit-sharing mechanism, poor governance, and inadequate information hinder mitigation efforts. Chapter 4’s findings revealed four dominant normative perspectives: a) government-led zero flaring policy; b) multi-scalar economic governance; c) business responsibility and social license; and d) localism and community empowerment. In addition, it revealed that first, there is strong stakeholder support for zero-flaring globally. Second, coordinated multi-scalar governance from international-national-local regulatory authorities is desired to protect marginalised communities. Third, egalitarian rights-based approaches are prioritised over utilitarian approaches in planning for oil and gas extraction. Fourth, business responsibility necessitates transparent communication of flaring activities and impacts and the Polluter Pays Principle of environmental redress to affected communities. Finally, stakeholder disagreement centres upon the practical mechanisms to achieve just outcomes - including compensation, the role of local authorities, regulatory agencies, Environmental Impact Assessment, and efforts to tackle rent-seeking and corruption.

The perspective on Zero-flaring globally underpins a government-driven ban on gas flaring. This initiative is based on cosmopolitan, procedural, and distributive justice principles, with a strong commitment to ending gas flaring. The approach involves creating a coalition of interested parties and taking collective action to effectively implement regulatory changes and legislation to reduce emissions. This stance is based on the belief in equal treatment for all, in line with cosmopolitan justice principles. Supporters of this perspective rejected traditional justifications that prioritise business interests over environmental concerns.

The concept of coordinated multi-scalar governance from international-national-local regulatory authorities is desired to protect marginalised communities aimed to address the issue of gas flaring injustice through multi-scalar governance and financial redress. Advocates of this perspective strongly support a global zero-flaring policy, which can be achieved through international treaties and government monitoring to achieve net zero-flaring. The focus is primarily on technocratic governance at both national and global levels. Compensation to affected communities, such as subsidised electricity, is seen to distribute redress for environmental injustice. Oil and gas are not seen as economically beneficial to the communities that support them, and there is uncertainty among advocates regarding broad government subsidies for the oil and gas industry. While there is support for economic compensation and other distributive benefits, there is less support for robust procedural justice mechanisms at the local level. As a result, this perspective can be viewed as supporting economic redistributive and top-down regulatory measures to prevent environmental injustices from occurring, but without community-level procedural or participatory decision-making control.

The egalitarian rights-based approaches prioritised over utilitarian approaches in planning for oil and gas extraction focused on the responsibility of businesses and governments to operate in a socially acceptable manner in the oil and gas sector. This also involves establishing trust and building relationships with communities during routine operations. Based on this perspective, this can be achieved by industry and government-led energy justice solutions, emphasising accountability, transparency, and good practice. Advocates of this perspective believed that gas flaring operations should be regulated and require participatory input to ensure that businesses follow best practices. This perspective believes a full environmental impact assessment should be conducted for gas flaring activities. This highlights the need for regulatory and participatory input in the governance of gas flaring operations due to a lack of trust in the industry's activities. Also, the perspective preferred market-based and business-led solutions, focusing on governance arrangements that promote accountability and community relationship building.

The involvement of communities in environmental decision-making and the fair distribution of benefits and costs are key aspects of localism and community empowerment. Community power is vital in deciding on gas developments within the areas where people live. Proponents argued that the revenue from gas production does not fully offset the environmental costs of gas flaring. This creates a need to balance the costs and benefits of oil and gas production to ensure fairness for local communities. One way to do this is by providing subsidised electricity or other benefits as compensation for hosting gas flaring operations. This stance on achieving environmental justice for communities affected by flaring is through EIA and economic redistribution measures to offset the adverse health and environmental impacts.

Stakeholder disagreements focused on finding practical ways to achieve equal and fair outcomes rather than the fundamental principles of justice that support a zero-flaring policy approach. These practical mechanisms can differ significantly and include things like community compensation measures (such as subsidised electricity and transboundary governance of compensation), the involvement of local authorities in governance and regulatory compliance, regulatory design (including Environmental Impact Assessment), and implementing the proper measures to combat rent-seeking and corruption.

Chapter 4's findings contribute to and underpin the overarching rationale for a net zero routine flaring target, a goal supported across a range of policy, NGOs, and industry stakeholder perspectives. Additionally, the chapter contribute to understanding the context-sensitivity of distributive, procedural, recognition, and cosmopolitan justice principles to gas flaring governance and how global gas flaring justice affects various scales.

Chapter 5 used insights from chapters 1-4 to inform the design of the Analytical Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (G-TOPSIS) survey. The chapter aimed to evaluate stakeholder preferences for different policies and regulatory options, determining the most optimised and effective to help eliminate routine gas-flaring by 2030 and achieve net zero emissions by 2050 whilst addressing good governance, justice, and fair implementation. Chapter 5 moved beyond traditional (business-as-usual) global gas flaring practices by demonstrating the use of an integrated approach incorporating literature and document review, interviews, expert surveys, AHP and G-TOPSIS to derive two competing stakeholder perspectives on gas flaring policy strategy. Consistency and policy coherence across oil and gas-producing and non-producing nations participating in flaring reduction initiatives were revealed as key policy goals. However, flaring mitigation policies have been approached primarily through individual country-level arrangements with concomitant effects on global environmental justice (Aigbe et al., 2023). A multi-level governance approach that fosters international cooperation and solidarity is desirable in ensuring fair and just emission reduction efforts based on shared goals and principles (IPCC, 2022; Nabernegg et al., 2019) in a way that addresses international and national needs. However, there is a lack of global environmental and flaring policies to control transboundary air pollution (Torre et al., 2021; Varkkey, 2019) and appropriate flaring policies and regulations when economic development policy decisions create transboundary pollution flows, which influences other countries' environmental management policy choices (Millimet, 2013).

Chapter Five's findings revealed two competing stakeholder perspectives, with differences revealed through the AHP ranking process of individual criteria. All gas flaring policy and regulatory framework criteria and sub-criteria identified were shown to be integral to achieving the targets. However, the individual criteria: "Policy and targets" and "Enabling framework", were deemed the most important. The "background and the role of reductions in meeting environmental and economic objectives" and "nonmonetary penalties" were the most crucial sub-criteria to abate global gas flaring. G-TOPSIS analyses showed that full implementation of gas flaring policies and regulatory framework criteria (Alternative 1), which could limit temperature rises to below the 1.5°C warming target, is considered the most effective alternative. These findings have implications for gas flaring policy strategies globally. These competing results and the business-as-usual approach to flaring mitigation policies, which currently supports individual country-level arrangements, may lead to more global environmental injustice (Aigbe, Cotton et al., 2023), raising the need for international cooperation on flaring mitigation. Achieving zero routine flaring and net-zero emissions targets thus requires a multi-level governance approach that promotes global collaboration and mutual support for equitable and sustainable emission reduction initiatives (IPCC, 2022; Nabernegg et al., 2019) in a manner that addresses both global and national needs.

The chapter underpins the idea that globally coordinated and uniform transnational policies and regulatory frameworks benchmark and reciprocal, legally binding agreements between countries to supplement national initiatives are imperative to improve the effectiveness of country-specific gas flaring policy strategies. Finally, these results provide tentative initial evidence that illustrates the importance of policy coherence (see Chapter 3), consistency, and fairness in constructing transnational policies and regulatory frameworks for gas flaring reduction, accompanied by a reciprocal, legally binding set of policies and agreements between countries to avoid ineffective individual abatement efforts (Chapter 5).

Based on the systems approach to global gas flaring issues and evidence provided throughout, there are key research themes that will be crucial to address to advance our comprehension of global gas flaring and develop effective management strategies. When taken collectively, five main themes and similar issues cutting across all gas flaring countries and several injustices were identified: Theme one relates to ambiguity in policy and power directions among the various authorities involved in gas flaring management. Theme two explores powerful industry interests. Theme three explores the economic and profits shaping decisions and implementation; theme four explores how voluntary agreements in global gas flaring management impact policy implementation; and theme five emphasises energy injustices and summarises the lifecycle stages of natural gas to gas flaring issues and injustices.

6.3.1. Ambiguity in Policy and Power Directions Among The Various Authorities Involved in Gas Flaring Management

Chapter 3 showed ambiguity in policy directions and unclear power structures among Nigeria's multiple agencies and authorities involved in gas flaring management. It also suggested a lack of coordination between different levels of government agencies tasked with gas flaring management. These issues have led to a constant need for policy prioritisation without clear central guidelines between gas flaring reduction goals and economic and other societal goals. These results are consistent with political barriers, regulatory governance, and organisation to gas flaring reduction issues identified by several authors (Altamirano-Cabrera et al., 2013; Ialongo et al., 2021; Loe & Ladehaug, 2012; Rodrigues, 2022; Shahab-Deljoo et al., 2023; Soltanieh et al., 2016; Wen et al. 2023), suggesting that failure to establish coherent environmental policies and regulatory measures due to conflicting policy goals with national measures or other sectors has remained a hindrance to global flaring reduction. Similarly, the evidence also reflects the findings of Agbonifo (2016); Babalola & Olawuyi (2022); Bello (2023); Fawole et al. (2016); Gerner et al. (2004); Mrabure & Ohimor (2020); Svensson (2005); Zhizhin et al. (2021), who also noted failures in the overall design and implementation of gas flaring policies, incoherent legislative and regulatory frameworks, non-transparent reporting and disclosure of statistical data, and in providing an enabling flaring framework including, e.g. fiscal and emission reduction incentives. This emphasises the implications of flaring mitigation policies approached through individual country-level arrangements, as suggested by Aigbe et al. (2023). Consistency and policy coherence across oil and gas-producing and non-producing nations participating in flaring reduction initiatives should be a key policy goal globally. As discussed in Chapter 5, it is crucial to establish policies and regulatory frameworks that prioritise coherence, consistency, and fairness across borders. To achieve this, globally coordinated and uniform transnational policies, regulations, and legally binding agreements between countries are crucial. These initiatives should supplement national policies to avoid ambiguity in policy and power directions among the various authorities involved.

The issue of outdated legal and regulatory provisions, in turn, contributes to the difficulty in monitoring and enforcing existing regulations (e.g., Buzcu-Guven & Harriss, 2014; Korppoo, 2018; Nelson, 2018; Olujobi, 2020; Olujobi et al., 2022; Olujobi & Olusola-Olujobi, 2020; Radhakrishnan et al., 2023) and ultimately ineffective penalties (usually fines) for breaching such regulations (e.g., Castelo Branco et al., 2010; Korppoo, 2018; Wen et al., 2023), providing further evidence that unclear power structures within the Nigerian multilevel governance system and the lack of policy coherence across sectors has negatively influence gas flaring policies' implementation. Explanations for these issues could be grounded in the broader challenges and politics in managing the trade-offs between fossil-fuel-based economic development and low-sustainable carbon and social development. Also, government ministry and agency restructuring across electoral cycles every four years with the federal government's strict political control over ministries/institutions and parastatal agencies have created barriers to long-lasting policy commitments, leading to policy U-turns political barriers, ambiguity and unclear power structures in the regulatory governance, and organisation.

As posited in Chapter 2, one of the main obstacles to gas flaring reduction, particularly in the Global South, is the lack of good governance, which spans the different interactions in the natural gas and gas flaring system as it connects multilevel governance and policy to energy justice issues. As identified by several authors (Rothstein, 2012; Sovacool & Dworkin, 2015; Van Veelen, 2018), good governance is crucial in global gas flaring management. In Norway, for instance, the Ministry of Petroleum Energy (MPE) oversees gas flaring and venting policies, regulations, and enforcement through the Norwegian Petroleum Directorate (NPD). The Norwegian Ministry of Climate and Environment creates comprehensive climate and environmental policies, while the Norwegian Environment Agency is the environmental regulator under its authority. This clear power structure and good governance have reduced corruption, enhanced industry accountability, and facilitated monitoring and enforcement of gas flaring policies and regulations in the Norwegian oil and gas sector (The World Bank, 2021). Creating strong institutions unswayed by political interference and biased or partisan policies that consistently sustain policies and regulations despite the election cycle would improve policy consistency, coherence, and good governance and is a key recommendation emerging from this thesis.

Despite the success recorded by Norway in their gas flaring reduction strategy, some governments, particularly in the Global South, Nigeria, for example, continue to lack the capacity and political will to implement such changes due to rent-seeking and corruption. This is consistent with the literature (e.g., Akinola, 2018; Iornumbe, 2019; Benson, 2020; Olujobi and Olusola-Olujobi, 2020), which has argued that there is a lack of political will to end gas flaring attributed to Nigeria's Federal Government's, and other stakeholders continued economic interest in fossil fuel extractivism. The Ministry of Petroleum Resources (MPR) is the main federal executive organ responsible for articulating and implementing petroleum resources policies, maintaining standards, monitoring quality and quantity, and regulating industry practices in Nigeria. Accordingly, the minister has discretionary prerogative powers to grant flaring. However, the dual role and overlapping responsibilities of the Nigerian president and the petroleum minister over the years have created unclear power distributions, unclear direction, and policy conflicts. It has also disrupted the functioning of the MPR. Appointing a capable and experienced minister is vital to minimise ambiguity in policy and power directions and ensure effective leadership and direction. Additionally, it is essential to maintain an appropriate distance between the minister and the president, allowing the president to observe and provide guidance on any necessary interventions in case of inconsistencies. Therefore, both past and current policy framing, governance and political decisions have all had and will continue to have a significant impact on Nigeria's gas flaring reduction strategies and the broader Zero Routine Flaring and the 2050 Net Zero Emissions targets. As shown in

Chapter 3, rent-seeking, lack of transparency, and weak industry accountability in oil-rich developing nations weaken gas flaring abatement policies and regulations. While this is particularly evident in countries with a unitary system of government, these influences strongly shape the multilevel governance structure and policy coherence, resulting in a lack of coordinated action and political will to end gas flaring. However, implementing the Extractive Industries Transparency Initiative (EITI) as one of the global standards could effectively combat corruption, including rent-seeking and promote transparency and accountability in the oil and gas sector (Okada & Shinkuma, 2022).

6.3.2. Powerful Industry Interests

Another noteworthy dimension of global gas flaring issues that emerged from the findings is the involvement of influential industry stakeholders. Economic and political structures on a large scale influence a country's climate change and gas flaring reduction policy goals. These include the dominance of fossil fuel industries and industry actors influencing policy outcomes, which can significantly impact policy decisions. Based on the three analytical chapters of this thesis, stakeholders perceive that the political elites do not fully acknowledge the negative impacts of gas flaring on the communities hosting the gas production facilities. Despite this, they reap benefits from natural gas production, consumption, and flaring. This suggests that the political barriers to gas flaring reduction involve a combination of state and industry actors influencing policy outcomes, environmental laws, and implementation measures (Willyard, 2019).

Powerful industry actors who promote fossil fuel lobbying interests create a range of institutional challenges and policy deficits (Giwa et al., 2017; Scheren et al., 2002), (re)producing failures of institutional capability to meet environmental protection goals (Hassan and Kouhy, 2013; Nelson, 2015; Nelson et al., 2017; Korppoo, 2018; Olujobi, 2020; Olujobi et al., 2022). For example, in Chapter 5, the literature review highlighted that the involvement and dominance of powerful state and industry actors in policy decisions, gas flaring laws, and policy in Texas have led to weak implementation (Willyard, 2019). Hence, countries whose economies heavily rely on fossil fuels may have less motivation to take significant action against gas flaring. Although it is insufficient to solely rely on these general factors at play to explain why the fossil fuel industry can undermine policies related to the environment, experts have argued explicitly that the dominant position of the fossil fuel sector has a significant impact on its environmental policies (Ylä-Anttila et al., 2018). More specifically, dependency on petroleum is considered to have caused political instability in developing countries due to three main features of the rentier state, including a weak institutional capacity, a distributive political economy, and elite capture and predation (Barma, 2021). Accordingly, environmental efforts to reduce flaring globally have been hindered by countervailing forces such as the free-rider problem and the discounting of future climate change mitigation benefits by powerful industry interests. This demonstrates how political and institutional arrangements shape environmental and, most importantly, gas flaring policies, particularly in countries whose economies rely heavily on fossil fuels, such as Nigeria (Chapter 3).

While Nigeria may share similarities with other countries that engage in gas flaring, consideration of existing legal and regulatory frameworks across Chapters 1-5 revealed that alternative methods for addressing routine flaring and venting can yield better outcomes than those achieved thus far. However, as stated by several authors, outdated regulations, a lack of capacity to monitor and enforce existing rules, an insufficiently integrated domestic gas value chain, and a lack of consideration of external factors hinder the effectiveness of even well-intentioned laws and regulations (Buzcu-Guven & Harriss, 2014; Korppoo, 2018; Nelson, 2018; Olujobi, 2020; Olujobi et al., 2022; Olujobi & Olusola-Olujobi, 2020; Radhakrishnan et al., 2023). On the contrary, Norway and Canada, with huge hydrocarbon reserves and major exporters of crude oil (like Nigeria and other top gas flaring nations), have the lowest flaring intensity among all countries reviewed from 2012 to 2021. Despite increasing oil production, Norway reduced flaring emissions by over 80% since the mid-1990s using economic tools such as emissions trading and a CO_2 tax to encourage companies to reduce their greenhouse gas emissions (The World Bank, 2021). Canada ranked 24th out of the top 30 countries for flaring in 2021, with a total of 1,077 million m^3. This marks a significant (48 %) reduction from the 2014 level of 2,063 million m^3. Despite being the world's fourth-largest oil and natural gas producer, Canada's contribution to global gas flaring in 2021 was only 0.8% (Johnson & Coderre, 2012). More importantly, Norway and Canada have robust policies and regulations in place. However, to address the issue of dominant industry interests, it is crucial to establish effective regulatory governance and strengthen institutions in nations that heavily depend on fossil fuels. Norway and Canada serve as an example of consistently upholding global standards through good governance, offering lessons to other gas flaring nations.

6.3.3. Economics and Profits Shaping Decisions and Implementation

Reducing global flaring and emissions in a general sense has faced obstacles due to factors such as economic benefits, the free-rider problem, and undervaluing of the future benefits of climate change mitigation by the political elite despite democratic efforts to reduce emissions (Battig & Bernauer, 2009). This thesis has shown that political and institutional arrangements are key in shaping environmental policies, including gas flaring policies (Congleton, 1992). Economic interests heavily influence the government's involvement in managing gas flaring in maintaining the current state of the gas sector, while environmental concerns are often secondary to generating wealth. As a result, there is a gap between the laws on flaring and the enforcement of environmental protection measures. This gap exists because enforcing environmental protection measures could negatively impact the IOCs and the government concerning economic benefits from gas flaring. Accordingly, there is a utilitarian approach to balancing the economic benefits of gas flaring at a national level with the environmental and social development burdens the host communities face. For example, Chapter 3 suggested that rent-seeking has been and still is a major concern for oil and gas-producing countries, particularly the global south, with its negative correlation to the resource curse and Dutch disease leading to a persistent lack of transparency, industry accountability, and substantial revenue accumulation by influential groups or individuals in Nigeria flaring system (Apergis & Katsaiti, 2018; Goumandakoye, 2016; Idemudia, 2012; Hasan & Perot, 2021; Oduyemi et al., 2021; Watts, 2004). Accordingly, gas flaring is often a result of bad economic decisions, short-term thinking, and a focus on immediate profits. In many cases, oil companies and governments of gas-flaring nations are more concerned with financial benefits in the form of rent-seeking than considering the long-term consequences of their actions. Thus, the decision to flare gas is often based on a lack of planning or inadequate investment in infrastructure to capture or utilise the gas.

Poor countries are relatively resource-dependent (Barbier, 2005), which can often lead to negative consequences such as the resource curse, Dutch Disease, and rent-seeking. Studies have shown that countries with abundant natural resources tend to have slower growth rates than those without. Additionally, social conflicts may arise as different groups compete for control over these resources. Natural resources can, however, be a blessing or a curse, depending on their governance. Angola and Nigeria have experienced negative effects due to their abundant natural resources, while Botswana and Norway have benefited from them. Studies have shown that the abundance of natural resources in Nigeria has led to intense fighting and rent-seeking, resulting in weak property rights and low per capita incomes. However, in Norway, where ethnic fractionalisation is only 0.06, and almost everyone belongs to the same ethnic group, there are no class struggles or other reasons for social fragmentation. As a result, there are effective property rights, and oil windfalls are a blessing (Hodler, 2006). In these countries abundant with resources, some groups (e.g., powerful industry interests – see previous section) can oppose specific policies. This indicates the complex interactions between institutions, interest groups, and voters. However, Norway avoided the negative effects of resource dependency and economic downturn by limiting rent-seeking activities, controlling the flow of resources, managing spending, and addressing the impact of spillover losses. They achieved this by implementing a centralised wage system that limited sector-wide pay increases, maintaining fiscal discipline, and benefiting from offshore oil revenue to control spending and losses. Additionally, their industrial policy encouraged diversity and learning, while social norms, an effective judicial system, and a fair wage negotiation system reduced rent-seeking (Larsen, 2006). As demonstrated by Norway, creating strong regulatory institutions and organisational structures, and upholding human rights and the rule of law can effectively address these challenges.

Another notable obstacle is that oil and gas companies and their investors prioritise investment in compliance with legislative and regulatory requirements over voluntary emissions reduction programs (Alsaifi et al., 2020; Lutsey & Sperling, 2007), particularly when profit is prioritised over emission reduction (Friedman, 1970, 2007). The implication is that without more robust global governance on flaring and its translation into domestic regulatory practice, nations without oil and gas resources may push for stricter policies and functional regulatory frameworks in low-income developing oil and gas-producing countries (Jost et al., 2019). However, due to economic benefits and profits, influential individuals and oil and gas companies lobbying against measures to reduce gas flaring could result in inadequate domestic regulatory compliance, monitoring, and reporting. These explanations corroborate why certain countries have implemented more extensive strategies to reduce greenhouse gas emissions than others (Ylä-Anttila et al., 2018). Chapter 5's findings and consultations held by GGFR/The World Bank between 2004 and 2022 all found that effective gas flaring policies, regulatory frameworks, and enforcement measures are necessary to reduce resource wastage and air pollution from the oil and gas industry. This includes measurement and reporting standards, sanctions for noncompliance, and economic incentives to encourage producers to reduce gas flaring and venting. This is supported by several studies that suggested that functional policy implementation (Korppoo, 2018; Ylä-Anttila et al., 2018), an enabling framework including fiscal incentives and emission reduction incentives for investments and a strong natural gas market and tax reductions (Svensson, 2005; Castelo Branco, Szklo and Schaeffer, 2010; Buzcu-Guven and Harriss, 2014; Olusegun Fawole, Cai and Mackenzie, 2016; Korppoo, 2018; Olujobi and Olusola-Olujobi, 2020; Wen, Xiao and Peng, 2023), coherent environmental policies and regulatory measures (Altamirano-Cabrera et al., 2013; Ialongo et al., 2021; Soltanieh et al., 2016; Wen et al., 2023), and transparency and industry accountability (e.g., Watts, 2004; Idemudia, 2012; Symons, 2016; Oduyemi, Owoeye and Adekoya, 2021), are all elements of robust global good governance that can be effectively deployed to reduce flaring to meet the zero routine flaring target.

6.3.4. Voluntary Emissions and Gas Flaring Reduction Agreements

Since the Paris Agreement, global governance of climate change mitigation, including gas flaring, has been under voluntary arrangements through Nationally Determined Contributions (NDCs) to the UNFCCC. This was further reinforced at COP26 and COP27 in 2021 and 2022. Accordingly, the policies required to mitigate flaring have been approached through individual country-level arrangements and under voluntary emissions and gas flaring reduction agreements within the Intended Nationally Determined Contributions (INDCs) (UNFCCC, 2021, 2022). Additionally, literature on comparative politics of climate policy suggests cross-national variation in instrument selection by governments to reduce emissions, including gas flaring (Harrison & Sundstrom, 2010; Rabe, 2007; Selin & VanDeveer, 2009). While it is desirable for IOCs to disclose their gas flaring emissions voluntarily, the quality of GHG emissions reporting is still a matter of dispute. Research shows that when companies disclose their emissions voluntarily, shareholders tend to react reflexively by superficially enhancing disclosure when there is public controversy or increased public scrutiny (Andrew & Cortese, 2011; Kolk et al., 2008; Stanny & Ely, 2008; Sullivan & Gouldson, 2012; Unerman & O'dwyer, 2007). While flaring reduction has become a pressing concern globally, it is managed through voluntary agreements rather than top-down international-to-national policy transfers. This finding implies that while countries without oil and gas resources lobby for more stringent policies and functional regulatory frameworks in low-income developing oil and gas-producing nations (Jost et al., 2019), oil and gas companies, influential industry stakeholders and governments of countries with oil and gas resources continue to rally against such initiatives. These findings are consistent with other research, which found NDCs are currently vague and lenient, resulting in lapses in compliance, monitoring, and reporting, while firms often prefer voluntary environmental management programs as a popular instrument of environmental policy (Rezessy and Bertoldi, 2011). Although Li (2017) suggests that a voluntary disclosure programme and mandatory regulations may support higher incentives for firms to invest in cleaner technology, such a programme's capacity to limit emissions is still uncertain. Gallo et al.'s. (2016) analysis shows that voluntary agreements (including NDCs) lack accurate accounting, monitoring, and validation, leading to slow-paced voluntary emission reduction projects across the European Union despite their potential. These factors, including economic and technical feasibility, international aid, responsibility and equality, public perceptions and stakeholder engagement, international pressure and country image, and political factors might all constitute potential drivers for NDCs' failure or success (Zheng et al., 2021) and ultimately gas flaring reduction failures globally. As illustrated in Chapter 5's findings, there is a need for policy coherence, consistency, and fairness in constructing transnational policies and regulatory frameworks for gas flaring reduction, accompanied by a reciprocal, legally binding set of policies and agreements between countries to avoid ineffective individual country-specific/voluntary agreements abatement efforts. However, to tackle global gas flaring, there is a need to combine policy measures through international cooperation and national legislation (Siriwardana & Nong, 2021), to counterbalance the weakness of voluntary emissions and gas flaring reduction agreements.

6.3.5. Energy (In)justices

As energy justice literature broadens its scope, there is a growing emphasis on this topic (Goldthau & Sovacool, 2012; Jenkins et al., 2014, 2016, 2017; Sovacool & Dworkin, 2015) in relation to gas flaring. As is evident in Chapter 2 Figure 2.1, and Tables 2.1 and 2.2, there are several issues and instances of injustice identified during natural gas extraction and production, consumption, and waste disposal (flaring) (Cross & Murray, 2018; Mulvaney, 2013) at a range of scales (Table 2.2). These connections are also related to the injustices outlined in Table 6.1 and Figure 6.1 on a larger scale. While most injustices occur locally, a significant number extend to the national scale, with a few at the global scale. Impacts of global gas flaring are not limited to the country where the flaring occurs but are interconnected and enmeshed in complex multilevel networks, underscoring the need for multilevel governance enquiry, such as that provided by this thesis.

Reducing global gas flaring requires integrating multilevel governance, policy coherence, good governance, and energy justice. From a multilevel governance perspective, spatial energy injustice challenges effective governance at multiple levels, requiring greater coordination and cooperation between different levels of government and stakeholders in the energy sector. The systems approach highlights the interconnectedness of elements within the gas flaring and the entire energy system. Consequently, spatial energy injustice can disrupt this balance. This points toward collaboration and coordination across different levels of government and sectors as being essential and further underscores the need to combine policy action through multilevel initiatives that link international cooperation, national legislation, and local action (Aigbe et al., 2023; Siriwardana & Nong, 2021). Table 6.1 displays issues and injustices throughout the natural gas lifecycle, including extraction, production, consumption, and waste disposal (specifically gas flaring) and their solutions. Also, the negative impacts of gas flaring affect not only the duration but also the timing of benefits and long-term consequences for future generations.

Table 6.1. Summary of lifecycle stages of natural gas to gas flaring issues, injustices, and a whole system solutions approach.

	Natural gas extraction and production	**Natural gas consumption**	**Gas flaring**	**Solutions**
Multilevel governance linked to Chapter 3.	• Complex multi-level governance system. • Multiple roles/agencies. • Unclear power structures between the governments and IOCs. • Political impacts of natural gas extraction. • Lack of trust in politicians/IOCs.	• Multiple roles or agencies. • Complex multi-level governance system. • Weak natural gas markets.	• Complex multi-level governance system. • Unclear power structures. • Multiple roles or agencies. • Inadequate investment in regulating and enforcing gas flaring. • Lack of trust in politicians/IOCs.	• Enhance the capacity of the multi-level system at every level to improve gas flaring governance. Each level presents unique opportunities for innovation and learning. • Encourage horizontal networks • Use the various global gas flaring protection levels through efficient governance to achieve maximum potential. • Establish a shared understanding and goal structure to ensure collective security. • Develop policies by incorporating the most effective existing practices from different levels. • Whenever possible, express gas flaring policy objectives as co-benefits. • Enable participation in diverse networks. National leadership demands participation in diverse networks, and healthy competition between and within states can drive progress in climate governance.

Policy coherence linked to Chapter 3.	• Policy incoherence • Conflicting policy goals	• Ambiguity in natural gas market policy directions. • Weak policy implementation.	• Weak gas flaring policy implementation. • Conflicting policy goals between gas flaring policies and national measures or other sectors. • Policy incoherence between gas flaring policies and other policies.	• Create and enhance monitoring and feedback mechanisms for global gas flaring governance policy impact and improvement.
Good governance linked to Chapters 3-5.	• Dispossession (human rights/rule of law). • The slow violence of landscape destruction, water contamination, and livelihood disruption- farmland and drinking water. • Impacts wildlife and water resources (contaminates water). • Reduce property values in extraction proximity. • Disturb local communities. • Natural gas production produces air pollution and waste.	• Energy poverty (lack of energy access). • Underdeveloped local markets for natural gas. • Lack of infrastructure to transport natural gas for local consumption. • Subsidies corruption. • Social marginalisation (lack of participation by all people). • Safety, reliability, and national accident (gas explosions).	• Dispossession (human rights/rule of law). • Environmental impacts of natural gas extraction and gas flaring. • Hazardous waste streams (volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs). • Transboundary socio-environmental injustices, conflicts, and pollution. • Sacrifice zone (environmental injustice). • Unequal distribution of costs and benefits of natural gas and flaring. • Ineffective Environmental Impact Assessment (EIA). • Lack of empowerment for the National regulatory agencies.	• Ensure that human rights are fully respected, and the rule of law is upheld. This can be achieved through effective participation, partnerships between multiple actors, political pluralism, transparent and accountable processes and institutions, and an efficient and effective public sector. • Legitimacy, access to knowledge, information, and education, political empowerment of individuals, equity, sustainability, and fostering attitudes and values that promote responsibility, collaboration, and tolerance is also crucial. • Initiatives for transparency in extractive industries, energy impact assessments, and legal aid for vulnerable groups. • Eliminating inappropriate subsidies, conducting impact assessments of subsidies, and providing adjustment

	• Loss of jobs (IOCs export labour in the form of expatriates to the enclave regions). • Traffic congestion. Lack of transparency around extraction.	• High household energy prices for poor villagers. • Lack of incentives and natural gas subsidies for local host communities.	• Health complications (birth defects and certain cancers). • Reduce property values in flaring proximity. • Impact on livelihoods and daily quality of life. • Local pollution and waste. • Corruption, lack of transparency and industry accountability.	packages for those dependent on subsidies. • A comprehensive strategy involving cooperation among various stakeholders, including government, businesses, and civil society, at all global gas flaring governance levels is required to address global gas flaring effectively.
Energy justice linked to Chapter 4	• Undermining the protection of human rights through dispossession and displacement of the local host community by physical force, coercion, and intimidation (rule of law). • Community health (public goods). • Lack of infrastructure in rural host communities (public goods).	• Lack of transparency and industry accountability. • Lack of infrastructure in rural host communities.	• Political impacts of gas flaring (lack of trust in politicians). • Lack of trust in politicians/IOCs (long-term community trust). • Inaccessible natural gas. development information impacts • Lack of voluntary disclosure of gas flaring emissions. • Non-availability of data on gas flaring emissions, health impacts, and distribution patterns. • Non-recognition of host communities' concerns about	• Lower levels of government should be supported and encouraged to connect through networking and learning from each other. • Local communities should be financially and institutionally strengthened and given a voice on the global stage. • Additionally, interactive learning channels should be provided or improved. It is also essential to increase the visibility and showcase the effectiveness of best practices. • Implement the Extractive Industries Transparency Initiative (EITI) as a global standard to effectively combat corruption, including rent-seeking and

	• Rent-seeking and corruption. • Lack of transparency. • Diversion of taxes through government subsidies and incentives. • Political impacts of natural gas extraction (lack of trust in politicians/IOCs).		natural gas extraction and gas flaring impacts and development decisions. • Non-involvement of state and local government agencies. • Impacts clean water and green space for local host communities. • Interference with other neighbouring countries transitions.	promote transparency and accountability in the oil and gas sector.
Other issues liked to Chapters 3-5.	• Economic benefits of natural gas extraction/production over health and the environment.	• Economic benefits of natural gas over health and the environment.	• Economic benefits of gas flaring over health and the environment. • Voluntary emissions and gas flaring reduction agreement. • Powerful industry interests.	• Enable functional policy implementation, fiscal incentives and emission reduction incentives for investments, a strong natural gas market, tax reductions, coherent environmental policies and regulatory measures, transparency, and industry accountability. • Adopting a technology-based approach to global gas flaring policy is also essential.

6.4. Advances and Policy Relevance

AHP and G-TOPSIS methods offer efficient ways of conducting social science research on global gas flaring and energy as a whole, in line with the systems approach in this thesis. AHP assigns weights to compare alternatives and parameters, providing a solid framework for prioritising and rating issues, and enabling me to create a hierarchical model for effective formulation and decision-making (Balubaid et al., 2015). Also, it allowed for flexibly incorporating objective value evidence, subjective judgments, and expert knowledge (Pohekar & Ramachandran, 2004). G-TOPSIS is highly regarded for its ability to adapt to various situations and requirements. In uncertain decision-making, G-TOPSIS can enhance decision-making precision (Arabameri et al., 2020), which is particularly useful for exploring climate change and energy topics, where issues such as energy production, consumption, and waste management are intertwined with potential solutions to climate change (Shaw, 2011). Accordingly, the AHP and the G-TOPSIS enhanced the quality of decisions concerning gas flaring policies and regulatory optimisation.

Countries have different responses to gas flaring and climate policies, with some progressing towards renewable energy and decarbonisation while others resist and continue relying on fossil fuels. This thesis's system model approach can be useful to understand better the cultural and political aspects of energy policy and the transformation of energy systems in various societies.

The findings of this thesis have great importance in terms of policy and implications for global gas flaring policies and practices. Addressing the negative social and environmental impacts of natural gas and gas flaring systems is not just a matter of technological solutions. It also involves political, social, and economic considerations, like addressing climate change (Bridge & Dodge, 2022; Jenkins et al., 2017; Nilsson et al., 2011). International scientific organisations such as the IPCC also acknowledge that the challenges associated with climate change are not solely scientific or technological but also heavily influenced by political and cultural factors (IPCC, 2023). Results obtained from this cross-national gas flaring research can contribute to the IPCC's analysis of the social and political aspects of climate change, specifically global gas flaring. This approach to this thesis analysis aligns with the post-Paris Accord emphasis on continuous research that monitors and aids the implementation of national targets for climate change mitigation, including gas flaring.

6.5. Implications for Policies and Practice and Recommendations

While chapter 3 focused on Nigeria, the emerging recommendations are relevant for advancing effective gas flaring reduction mechanisms more widely. They could be used as a benchmark in other countries to help meet the global 2030 zero routine flaring and net zero emissions targets. It is also important to conduct rigorous impact assessments and conservation planning in oil and gas-producing host communities to predict the development of settlements near production areas and ensure a fair balance between natural resources, other livelihoods, and conservation plans. This approach should be applied globally to all host communities, particularly in the Global South, where there is a lack of research and inadequate environmental management.

Improving the transparency and accountability of oil and gas companies, especially within the global Extractive Industries Transparency Initiative framework (Corrigan, 2017; Haufler, 2010; Lujala, 2018; Van Alstine, 2017) is essential. This could enhance their role as responsible representatives for sustainable economic development, in line with the UN Sustainable Development Goals (Ali et al., 2017; Dialga, 2018). Taking a proactive approach could benefit many threatened ecosystems and millions of people living in gas flaring regions during and after oil and natural gas operations. In summary, I suggest a range of policy proposals to address these issues and prevent or minimise injustice associated with gas flaring based on the knowledge gained from this thesis (Table 6.2).

Table 6.2. Policy recommendations on global gas flaring abatement emerging directly from the findings of this thesis

Multi-level governance, policy coherence and good governance	**Energy Justice and good governance**	**Optimising policies and regulations for zero routine gas flaring and net zero**
• Governments should demonstrate the political will to end gas flaring by establishing robust institutions. • Economic diversification is crucial to prevent heavy reliance on oil and gas revenue, especially in developing countries. This involves promoting industrialisation and structural transformation to stimulate growth in all sectors of the economy and reduce the negative effects of rent-seeking and the resource curse. • Previous policy solutions overlook the importance of empowering local environmental gas flaring management and restoration.	• To combat energy poverty, governments need to provide electricity subsidies to communities affected by gas flaring and establish infrastructure for natural gas transportation for local use. • Governments of countries that flare gas and IOCs must discourage the development of isolated communities by promoting local resources, supply chains, and labour. To harness the benefits of natural resources, it is recommended that countries invest in human and physical capital to enable practitioners and market participants to fully engage in the extraction and processing of natural resources within the country. This will significantly boost the growth of the country's local industries and non-natural resource sectors. • Oil and gas companies should take it upon themselves to abide by the polluter pays principles.	• Governments should agree and establish consistent and fair transnational policies and regulatory frameworks to reduce gas flaring. This should be accompanied by legally binding agreements between countries to ensure reciprocity and accountability. This will improve policy coherence and promote effective implementation. • Develop plans to reduce flaring and promote collaboration among stakeholders: It is recommended that countries develop strategies to reduce gas flaring and promote collaboration among stakeholders. When developing new projects, companies should consider ways to avoid flaring, use associated gas productively, or safely reinject it. Regulators should require operators to assess the best way to capture, compress, or utilise flared gas for existing fields. Smaller operators may face challenges implementing flaring reduction techniques without economies of scale. Legal ownership of associated gas in some regions may also hinder investment in gas recovery and sales. To eliminate non-routine flaring, well-designed contracts and regulations are crucial to encourage cooperation among upstream and midstream operators.

Thus, financial, and technological investments should be tied to protecting the environment through local governance. • Developing nations flaring gas can prevent negative effects like the Resource Curse, Dutch Disease, and economic slowdowns by avoiding over-reliance on natural resources. To achieve this, governments should implement policies encouraging diversification and industrialisation to support growth in other sectors rather than focusing solely on resource rents. • To improve transparency, involving the public in gas flaring projects is important. This can be done by providing information on how the local community can meaningfully participate in decision-making.	• Governments should incorporate the interests and concerns of the communities hosting gas flaring into the decision-making process of governments regarding oil and gas exploration and development. • Relevant public authorities should establish independent watchdog groups responsible for examining, monitoring, and reviewing government regulatory agencies. • Require IOCs to conduct a comprehensive Environmental Impact Assessment (EIA) and Strategic Environmental Assessments (SEA). • Ensure that host communities are represented fairly and adequately in the gas flaring processes. • It is essential to refrain from using physical threats by the government and instead promote open communication with the host communities. This can be achieved by upholding human rights and the rule of law. • By establishing a fair and efficient judicial system, governments should ensure that communities are not deprived of their land and means of living.	• To ensure transparency, measuring reporting flaring and venting emissions is essential to: *a.* Monitor data reported on flaring and combustion efficiencies. This is often estimated and can vary significantly from the recorded volumes during measurement campaigns. Measuring flaring and venting levels is necessary to provide accurate data for developing problem-solving solutions and lay the groundwork for market-based mechanisms that support low-emission oil and gas sources. *b.* Publicly release measurements to aid buyers and consumers in comprehending scope 1 emissions. *c.* Use satellites to track flaring and methane emissions. This is an emerging area that can aid regulators in monitoring operational practices, detecting leaks promptly, and ensuring that flaring penalties are being paid to host governments. Nonetheless, satellites may not be able to detect all instances of flaring, and bottom-up measurement campaigns are still the preferred method for designing flaring reduction regulations. • Reduce both present and future flaring levels: *a.* Although the demand for oil and natural gas significantly decreases in the Net Zero Emissions by 2050 Scenario, these resources remain important. Operators should install flare

• A better understanding of power structures can result in more efficient implementation, regulation, and enforcement of environmental policies. • Governments should appoint capable and experienced ministers who can minimise ambiguity in policy and power directions to ensure effective leadership and direction in gas flaring management policies. This will help in the effective implementation of policies. • To avoid conflicting policy goals between gas flaring policies and national measures or other sectors, it is important to promote policy coherence and reduce inconsistency across all sectors.	• To address the issue of gas flaring pollution in sacrifice zones, it is important to manage it carefully. This can be achieved by providing clean and accessible water services and green spaces for the local host communities affected by gas flaring. • Governments should establish and agree on international mechanisms and domestic policies to address transboundary pollution and other global externalities. • Nations that engage in heavy gas flaring should take steps to reduce the environmental impact of transboundary pollution. One way to do this is by compensating neighbouring countries affected by the pollution. • Governments should re-evaluate their approach and take proactive measures to restore communities that have been degraded. These actions should focus on prevention and planning for sustainability.	meters and use satellite data to monitor flares regularly to reduce emissions. This will help distinguish between emergency and non-emergency flaring. *b.* In addition, the timely development of associated gas infrastructure, flaring reduction technologies, and limits on the flaring intensity of oil production can help. *c.* New oil developments should also include the productive use of associated gas, and connections between upstream and midstream developments should be well-timed. Incentivising existing fields to implement gas capture and recovery techniques can eliminate all non-emergency flaring. *d.* Furthermore, flaring monitoring systems and optimising process controls can decrease flaring levels. Funding flaring reduction and elimination projects and technologies can also reduce supply chain emissions. *e.* Finally, requiring climate and environmental standards in the sale of oil and gas assets is essential.

6.6. Opportunities for Future Research

Like the energy transition system, the amount of global gas flaring is influenced in part by political alliances (Hess, 2018). The problems and solutions related to climate change and energy systems often extend beyond national boundaries and become topics of international political discussion. Although this thesis takes a global approach, representation was minimal. Future research could develop innovative ways to conduct cross-border or cross-cultural analyses to guide future policymaking and action on gas flaring, energy, and climate change. Further research is needed to investigate whether similar policy conflicts regarding gas flaring and other objectives arise in other nations that engage in gas flaring and to determine how such conflicts are addressed in various institutional contexts. Also, a comparative analysis to compare gas flaring with other transboundary commons issues is needed to investigate the possibility of transferring lessons learned from other environmental issues to address global gas flaring.

Q-methodology is advantageous for energy justice research as it generates significant results with small sample sizes and reduces researcher bias. The four factors derived in Chapter 4 only explained 58% of the data, leaving 42% unexplained. Q-methodology is based on a small-*n* P-set and purposive/snowball sampling techniques, allowing participants to enter with or without a code for anonymity. It is important to point out that in Q-method studies, the data collected reflects the overall discussion on the topic rather than a specific group of people. As a result, the findings cannot be applied to a larger population. To obtain more reliable and generalisable results at the population level, conducting a quantitative survey encompassing various demographics is necessary and could provide useful new insights that build from those emerging in the Q-study.

Chapter 5 provided projections and analysis of a specific period in the history of gas flaring and CO_2 emissions. Due to changes in trajectories, it is important to note that these projections, forecasts, and social contexts may change and potentially alter the projected scenarios. A possible area for future research in this regard is to examine current trajectories, projections, and forecasts to gain a more comprehensive understanding of the CO_2 and global gas flaring dynamics. Additionally, it would be valuable for future research to use this framework to analyse other sector policies and evaluate their effectiveness. The thesis's global field is incomplete and imbalanced, with limited representation from Russia, Latin America, the

Middle East, and Southeast Asia. It would be valuable to include new regional analyses to gain a more complex and holistic understanding of global gas flaring politics.

6.7. Conclusion

Gas flaring issues and injustices span various levels and scales. By taking a whole system approach, this thesis has contributed to gas flaring literature by providing insights through multilevel governance, policy coherence, good governance, and energy justice lenses to derive a framework demonstrating how a whole system thinking approach to global gas flaring issues can provide evidence to support efforts toward the goal of zero routine flaring and broader net zero emissions targets. A mixed method combined with a whole system approach has advanced understanding of the various connections within the global gas flaring system. It has also provided practical insights into the causes and consequences of gas flaring and raised awareness among policymakers, industry stakeholders, and the public.

In the fight against global gas flaring, national governments hold power and responsibility. They should lead in implementing bold and consistent gas flaring policies and assume final accountability in a complex system where responsibilities are often unclear. However, meeting the zero routine flaring and net zero emissions targets requires both a global and national approach with transparent governance and power structures, coherent policies, good governance, and justice considerations.

Based on the findings and new conceptualisation of whole systems to natural gas and global gas flaring, governments, planners, policymakers, practitioners, and researchers should become more aware of the potential for global gas flaring to create new issues and exacerbate pre-existing issues and injustices. Dealing with the adverse social and environmental effects of various environmental problems requires more than just technological fixes. It also involves considering political, social, and economic factors. The methodology and framework used in this thesis are significant for policymaking and have implications for addressing other environmental issues. Accordingly, results obtained from this cross-national gas flaring research can provide insights into the social and political dimensions of other environmental problems. This thesis has raised specific recommendations aimed at improving and minimising global gas flaring vulnerability, making benefits and burdens more visible, and implementing fair and consistent policies and regulations globally. Dealing with the whole complex system of global gas flaring is thus essential but also challenging.

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Appendices and Supplementary Materials

Chapter 1 Appendices

Appendix 1A: Environment Department, University of York Research Ethics Approval Form for Chapter 3

Environment Department, University of York
Research Ethics Approval Form

Read this first

Who should use this form?

You should only use this form if you are carrying out research or consultancy project through the Environment Dept, University of York: This includes:

Members of academic, research and SEIY staff
Honorary members of staff associated with the Department.
Research degree students (masters and PhD).
Undergraduate students and taught postgraduate students who are doing research projects.

Can I begin work before the project is ethically approved?

NO primary data collection can begin until you have approval from one of the following:

The Environment Dept Ethics Committee
An External Research Ethics Committee (NHS Research Ethics Committee, Lead Partner University etc)

What will happen if I proceed without approval or falsely self-certify research ethics approval?

Collecting primary data in the absence of ethical approval or falsely self-certifying the level of risk associated with a project will constitute a disciplinary offence. This will result in:

Student – Disciplinary action resulting in immediate failure in any module or project associated with the research and potentially dismissal from the University.

Staff - Disciplinary action which may potentially lead to dismissal.

If you do not have ethical approval, the University's insurers will not cover you for legal action or claims for injury. In addition, you may face debarment from membership of some professional or statutory bodies and excluded from applying for some types of employment or research funding opportunities. You may not be able to publish your research.

What happens if the project changes after approval?

If after receiving ethical approval your project changes such that the information provided in this form is no longer accurate, then the ethical approval is automatically suspended. You must re-apply for ethical approval immediately and stop research based on the suspended ethical approval.

Is there any help available to complete this form?

Guidance can be found in on the departmental website. Further advice is also available from the Departmental Ethics Committee.

Submit questions and applications to: environment-ethics@york.ac.uk

Environment Department, University of York

Research Ethics Approval Form

1 Project Information (Everyone) **a)** Title of Project Gas flaring in Nigeria: A multi-level governance and policy coherence analysis
b) Name of Principal Investigator (PI) or Research Student and Supervisor Godwin Aigbe goa507@york.ac.uk Professor Lindsay Stringer lindsay.stringer@york.ac.uk Professor Matthew Cotton m.cotton@tees.ac.uk
c) Degree course (students) or SEI-Y or Env Dept (staff) PhD in Human Geography and Environment
d) Names of Co-investigators (CIs) and their organisational affiliation
e) How many additional research staff will be gathering data for the project? Names and their organisational affiliation (if known) None
f) Proposed project start date (At least four weeks in the future)

03-05-2021
g) Estimated project end date 30-06-2023
h) Who is funding the project? Self-funded Has funding been confirmed? Yes
You may find the following codes of ethical practice and conduct relevant to your project: British Psychological Society code of conduct: http://www.bps.org.uk/the-society/code-of-conduct/code-ofconduct_home.cfm BCS Chartered Institute for IT Code of Conduct: http://www.bcs.org/server.php?show=nav.6030 Society of Environmental Toxicology and Chemistry (SETAC) code of ethics http://www.setac.org/?page=SETACEthics Guidelines for the Treatment of Animals in Behavioural Research and Teaching http://asab.nottingham.ac.uk/ethics/guidelines.php

Signatures

Submit this form and any attachments by e-mail including your surname in the filename.

You should type your name in the signature space.

An email attachment sent from your University inbox will be assumed to have been signed electronically.

Principal Investigator

Signed (**Godwin Aigbe**) (Principal Investigator or Student)

Date .19-04-2021

Students must ask their Project Supervisor to type their name here and submit your application. This email will be taken as an electronic countersignature

Countersigned (**Professor Lindsay Stringer**) (Student's Project supervisor)

Date .19-04-2021

I have read this form and confirm that it covers all the ethical issues raised by this project fully and frankly. I also confirm that these issues have been discussed with the student and will continue to be reviewed in the course of supervision.

Submit to: environment-ethics@york.ac.uk

For office use only

Date form initially received:	19/04/2021
1. Ethical review required	**Yes**
2. CRB check required	**No**
Exempted submitted to an external Research Ethics Committee	
3. External Research Ethics Committee (Name)	**No**
4. Copy of external ethical clearance received	DD/MM/YYYY
Ethics Panel Review	
5. Date sent to reviewer (Name)	21/04/2021 (McClean
Original Decision (Consultation with Chair UARC/Chair RDSC)	
7. Approve	**Yes**
8. Approve with conditions (specify)	**No**
9. Resubmission	**No**
10. Reject	**No**
11. Date of letter to applicant:	21/04/2021
Resubmission	
12. Date of receipt of resubmission:	
13. Date sent to reviewer 1 (Name)	
14. Date sent to reviewer 2 (Name)	
Final decision recorded	
15. Approve	
16. Approve with conditions (specify)	
17. Reject	
18. Date of letter to applicant:	

Signature ....Colin McClean...................... (Chair of Ethics Committee)
Date ....21/04/2021.........................

Appendix 1B: Environment Department, University of York Research Ethics Approval Form for Chapter 4

UNIVERSITY of York

Environment Department, University of York
Research Ethics Approval Form

Read this first

Who should use this form?

You should only use this form if you are carrying out research or consultancy project through the Environment Dept, University of York: This includes:

Members of academic, research and SEIY staff
Honorary members of staff associated with the Department.
Research degree students (masters and PhD).
Undergraduate students and taught postgraduate students who are doing research projects.

Can I begin work before the project is ethically approved?

NO primary data collection can begin until you have approval from one of the following:

The Environment Dept Ethics Committee
An External Research Ethics Committee (NHS Research Ethics Committee, Lead Partner University etc)

What will happen if I proceed without approval or falsely self-certify research ethics approval?

Collecting primary data in the absence of ethical approval or falsely self-certifying the level of risk associated with a project will constitute a disciplinary offence. This will result in:

Student – Disciplinary action resulting in immediate failure in any module or project associated with the research and potentially dismissal from the University.

Staff - Disciplinary action which may potentially lead to dismissal.

If you do not have ethical approval, the University's insurers will not cover you for legal action or claims for injury. In addition, you may face debarment from membership of some professional or statutory bodies and excluded from applying for some types of employment or research funding opportunities. You may not be able to publish your research.

What happens if the project changes after approval?

If after receiving ethical approval your project changes such that the information provided in this form is no longer accurate, then the ethical approval is automatically suspended. You must re-apply for ethical approval immediately and stop research based on the suspended ethical approval.

Is there any help available to complete this form?

Guidance can be found in on the departmental website. Further advice is also available from the Departmental Ethics Committee.

Submit questions and applications to: environment-ethics@york.ac.uk

Environment Department, University of York

Research Ethics Approval Form

1 Project Information (Everyone) **a)** Title of Project Global gas flaring and energy justice: An empirical ethics analysis of stakeholder perspectives
b) Name of Principal Investigator (PI) or Research Student and Supervisor Godwin Aigbe goa507@york.ac.uk Professor Lindsay Stringer lindsay.stringer@york.ac.uk Professor Matthew Cotton m.cotton@tees.ac.uk
c) Degree course (students) or SEI-Y or Env Dept (staff) PhD in Human Geography and Environment
d) Names of Co-investigators (CIs) and their organisational affiliation
e) How many additional research staff will be gathering data for the project? Names and their organisational affiliation (if known) None
f) Proposed project start date (At least four weeks in the future) 15-11-2021
g) Estimated project end date 30-06-2023
h) Who is funding the project?

Self-funded Has funding been confirmed? Yes
You may find the following codes of ethical practice and conduct relevant to your project: British Psychological Society code of conduct: http://www.bps.org.uk/the-society/code-of-conduct/code-ofconduct_home.cfm BCS Chartered Institute for IT Code of Conduct: http://www.bcs.org/server.php?show=nav.6030 Society of Environmental Toxicology and Chemistry (SETAC) code of ethics http://www.setac.org/?page=SETACEthics Guidelines for the Treatment of Animals in Behavioural Research and Teaching http://asab.nottingham.ac.uk/ethics/guidelines.php

Signatures

Submit this form and any attachments by e-mail including your surname in the filename.

You should type your name in the signature space.

An email attachment sent from your University inbox will be assumed to have been signed electronically.

Principal Investigator

Signed (**Godwin Aigbe**) (Principal Investigator or Student)

Date .19-10-2021

Students must ask their Project Supervisor to type their name here and submit your application. This email will be taken as an electronic countersignature

Countersigned (**Professor Lindsay Stringer**) (Student's Project supervisor)

Date .19-10-2021

I have read this form and confirm that it covers all the ethical issues raised by this project fully and frankly. I also confirm that these issues have been discussed with the student and will continue to be reviewed in the course of supervision.

Submit to: environment-ethics@york.ac.uk

For office use only

Date form initially received:	2/11/2021
1. Ethical review required	**Yes**
2. CRB check required	**No**
Exempted submitted to an external Research Ethics Committee	
3. External Research Ethics Committee (Name)	**No**
4. Copy of external ethical clearance received	DD/MM/YYYY
Ethics Panel Review	
5. Date sent to reviewer (Name)	16/11/2021
Original Decision (Consultation with Chair UARC/Chair RDSC	
7. Approve	**Yes**
8. Approve with conditions (specify)	**Yes** **Include university bases for data privacy regs (most information form standard privacy notice is given, just legal framework etc)**
9. Resubmission	**No**
10. Reject	**No**
11. Date of letter to applicant:	16/11/2021
Resubmission	
12. Date of receipt of resubmission:	
13. Date sent to reviewer 1 (Name)	
14. Date sent to reviewer 2 (Name)	
Final decision recorded	
15. Approve	
16. Approve with conditions (specify)	
17. Reject	

18. Date of letter to applicant:	

Signature ....Colin McClean..................... (Chair of Ethics Committee)
Date ....16/11/2021............................

Appendix 1C: Environment Department, University of York Research Ethics Approval Form for Chapter 5

UNIVERSITY of York

Environment Department, University of York
Research Ethics Approval Form

Read this first

Who should use this form?

You should only use this form if you are carrying out research or consultancy project through the Environment Dept, University of York: This includes:

Members of academic, research and SEIY staff
Honorary members of staff associated with the Department.
Research degree students (masters and PhD).
Undergraduate students and taught postgraduate students who are doing research projects.

Can I begin work before the project is ethically approved?
NO primary data collection can begin until you have approval from one of the following:

The Environment Dept Ethics Committee
An External Research Ethics Committee (NHS Research Ethics Committee, Lead Partner University etc)

What will happen if I proceed without approval or falsely self-certify research ethics approval?
Collecting primary data in the absence of ethical approval or falsely self-certifying the level of risk associated with a project will constitute a disciplinary offence. This will result in:

Student – Disciplinary action resulting in immediate failure in any module or project associated with the research and potentially dismissal from the University.

Staff - Disciplinary action which may potentially lead to dismissal.

If you do not have ethical approval, the University's insurers will not cover you for legal action or claims for injury. In addition, you may face debarment from membership of some professional or statutory bodies and excluded from applying for some types of employment or research funding opportunities. You may not be able to publish your research.

What happens if the project changes after approval?

If after receiving ethical approval your project changes such that the information provided in this form is no longer accurate, then the ethical approval is automatically suspended. You must re-apply for ethical approval immediately and stop research based on the suspended ethical approval.

Is there any help available to complete this form?

Guidance can be found in on the departmental website. Further advice is also available from the Departmental Ethics Committee.

Submit questions and applications to: environment-ethics@york.ac.uk

Environment Department, University of York

Research Ethics Approval Form

1 Project Information (Everyone) **a)** Title of Project Optimising policies and regulations for zero routine gas flaring and net zero
b) Name of Principal Investigator (PI) or Research Student and Supervisor Godwin Aigbe goa507@york.ac.uk Professor Lindsay Stringer lindsay.stringer@york.ac.uk Professor Matthew Cotton m.cotton@tees.ac.uk
c) Degree course (students) or SEI-Y or Env Dept (staff) PhD in Human Geography and Environment
d) Names of Co-investigators (CIs) and their organisational affiliation
e) How many additional research staff will be gathering data for the project?

Names and their organisational affiliation (if known) None
f) Proposed project start date (At least four weeks in the future) 21-11-2022
g) Estimated project end date 30-10-2023
h) Who is funding the project? Self-funded Has funding been confirmed? Yes
You may find the following codes of ethical practice and conduct relevant to your project: British Psychological Society code of conduct: http://www.bps.org.uk/the-society/code-of-conduct/code-ofconduct_home.cfm BCS Chartered Institute for IT Code of Conduct: http://www.bcs.org/server.php?show=nav.6030 Society of Environmental Toxicology and Chemistry (SETAC) code of ethics http://www.setac.org/?page=SETACEthics Guidelines for the Treatment of Animals in Behavioural Research and Teaching http://asab.nottingham.ac.uk/ethics/guidelines.php

Signatures

Submit this form and any attachments by e-mail including your surname in the filename.

You should type your name in the signature space.

An email attachment sent from your University inbox will be assumed to have been signed electronically.

Principal Investigator

Signed (**Godwin Aigbe**) (Principal Investigator or Student)

Date .06-11-2022

Students must ask their Project Supervisor to type their name here and submit your application.

This email will be taken as an electronic countersignature

Countersigned (**Professor Lindsay Stringer**) (Student's Project supervisor)

Date .06-11-2022

I have read this form and confirm that it covers all the ethical issues raised by this project fully and frankly. I also confirm that these issues have been discussed with the student and will continue to be reviewed in the course of supervision.

Submit to: environment-ethics@york.ac.uk

For office use only

Date form initially received:	**12/11/2022**
1. Ethical review required	**Yes**
2. CRB check required	**No**
Exempted submitted to an external Research Ethics Committee	
3. External Research Ethics Committee (Name)	
4. Copy of external ethical clearance received	DD/MM/YYYY
Ethics Panel Review	
5. Date sent to reviewer (Name)	**21/11/2022**
Original Decision (Consultation with Chair UARC/Chair RDSC)	
7. Approve	
8. Approve with conditions (specify)	
9. Resubmission	**Tidy up references to interviews**
10. Reject	
11. Date of letter to applicant:	**21/11/2022**
Resubmission	
12. Date of receipt of resubmission:	**25/11/2022**
13. Date sent to reviewer 1 (Name)	
14. Date sent to reviewer 2 (Name)	
Final decision recorded	
15. Approve	**02/12/2022**
16. Approve with conditions (specify)	

17. Reject	
18. Date of letter to applicant:	

Signature .....Colin McClean..... (Chair of Ethics Committee)
Date ....02/12/2022............

Chapter 3 Appendices

Appendix 3A: Zoom Video Interview Protocol

UNIVERSITY of York

Environment Department, University of York

Zoom Video Interview Protocol

Title of Project: Gas flaring in Nigeria-A multi-level governance and policy coherence analysis

Interview

Enumerator code……………………………………………………………………………….

Name of Respondent ………………………………………………………………………….

Address……………………………………………… City/Town/Village: ………………………

Division………………. Region: …………………………………………………………….

Date……………………Phone number…………………………………………………………...

Email Address……………………………………………………………………………………….

Your organisation: ………………………………………………………………………………….

Your Position: ………………………………………………………………………………………

Interview No: …………………………………………………………………………………….

Permission to record and Copyright waiver.

Section 1 – Introduction:

1. What are your primary responsibilities in your current role?

2. When did you become involved with gas flaring management?

Section 2 – Issues and Ideology:

3. What are the main issues that the federal government of Nigeria should focus on concerning gas flaring reduction policies?

Section 3 – Administrative Structures, Relationship Between Federal Institutions and Jurisdictional Conflicts

4. Who manages gas flaring and venting in Nigeria?
5. Strategically, does it matter which Federal institutions enforce regulations on gas flaring if all the Federal institutions tasked with environmental issues have a common goal of capping gas flaring?

Section 4 – Policy implementation/goal, Federalism and Stakeholders/Local Content

Policy implementation/goal

6. How well do you think the policy goals and preferences of different groups involved in Nigeria's gas flaring fit together?
7. To what extent do economic policies dominate environmental policies and concerns over flaring?
8. Do you think the interests of particular groups have played a role in limiting or facilitating the implementation of gas flaring policies?
9. Do you consider the 10 Naira/1000cf fine appropriate as a penalty seeking to reduce flaring?
10. What do you think about Nigeria's gas flaring penalty of 10 Naira/1000cf compared to penalties in other countries?

Federalism and Gas flaring Policies

11. Do you think the government should decentralise authority to the state and local governments and enable them to legislate and control gas flaring in the various gas flaring and venting states in the Niger Delta, or do you favour a centralised approach?
12. Do you think the state governments need more or less authority and power (autonomy) to combat gas flaring and venting, and why?
13. Do you think the local and state government priorities and politics concerning flaring match those of the national government?

Stakeholders/Local Content

14. Where do you think the federal government of Nigeria stands concerning stakeholders' involvement in flaring decision-making?
15. How important are strong local stakeholders/ host communities' involvement in the success of the gas flaring reduction target?

Section 5 – *International Oil Companies (IOCs), Government Policies, and Policy Implementation*

International Oil Companies (IOCs) and government policies

16. Do you think this has impacted the outcome of the gas flaring reduction target?
17. Do you think the influence of the IOCs weakens or strengthens interest in gas flaring policy implementation, or is it neutral? Please explain.

Policy implementation

18. The federal government of Nigeria control notable shares within the production sharing contract (PSCs) through the Ministry of Petroleum Resources (MPR) and Nigerian National Petroleum Corporation (NNPC). How do you think this affects the federal institutions' enforcement of gas flaring laws and regulations?

Is there anything relevant to the study that you would like to add?

Thank you for your co-operation.

Appendix 3B: Supplementary Material 1: Expert email interview/survey questionnaires

UNIVERSITY of York

Environment Department, University of York

Expert Email Interview/Survey Schedule

Title of Project: Gas flaring in Nigeria-A multi-level governance and policy coherence analysis

Preamble: Copyright waiver

Questionnaire

Enumerator code……………………………..………………..………………….………………

Name of Respondent ……….………………………………………………………………...

Address……………………………….……………………………………………..…….…
……………………………………………………………………………………….........

City/Town/Village: ………………………………………………………….…………

State……………………………Region: ……………………………….…………….…...

Date……………………….……Phone number……………………………………..….…

Email Address……………….……………………………………………………………….

Your organisation: ………………….……………………………………….………….

Your Position: ………………….………………………………………….………………

Questionnaire No: ……………….………………………………………….…………

<u>Section 1 – Introduction:</u>

1. What are your main responsibilities in your current role?
2. When did you become involved with gas flaring issues?

<u>Section 2 – Administrative structures, relationship Between federal Institutions and jurisdictional conflicts</u>

Relevant Federal institutions tasked with gas flaring and venting management

3. What role should a national oil company (NNPC) play in the oil and gas industry? ***Please type your preferred number between 1 and 5 in the box where necessary.***

	1=Strongly agree **2=Agree** **3=Undecided** **4=Disagree** **5=Strongly disagree**
Operator only	
Field management	
Be a regulator/policymaker	
Be vertically integrated	
Midstream (Storage, processing, and transportation of petroleum products)	

Upstream (exploration, drilling, and extraction of oil and gas) and Downstream (refining of petroleum crude oil and the processing and purifying of raw natural gas)	
Influence other government departments	
Investor	
Body to facilitate communication between Government and industry operators	
Redistribution of wealth, fuel subsidies,	
Technology transfer controls local content	
Should be commercially driven	
Be transparent and independent from the government	
Other strategic government objectives	

Administrative structures

4. In the Nigerian gas flaring management, are there compliance programmes and controls to prevent or detect possible instances of fraud and corruption?

1=Yes	2=Maybe	3=I Do not know	4=No Programme

4b. If yes, how effective do you believe these programmes are in Nigerian oil and gas management?

1=Very effective	2=Somewhat Effective	3=Effective	4=Unsure	5=Not effective

5. Federal institutions tasked with gas flaring and venting administrative structures.

	Yes	Maybe	No
5a. Are there administrative structures in place to manage gas flaring and venting in Nigeria?			

5b. Strategically, does it matter which of the federal institutions enforce regulations on gas flaring if all the institutions tasked with environmental issues have a common goal of capping gas flaring?			

<u>Section 3 – Federalism and Gas flaring Policies, Stakeholders/Local Content and Relevant Federal Government Institutions</u>

6. Policy goals/preference

	1=Strongly agree **2=Agree** **3=Undecided** **4=Disagree** **5=Strongly disagree**
6a. How well do you think the policy goals and preferences of different groups involved in Nigeria's gas flaring fit together?	
6b. To what extent do you agree/disagree that economic policies dominate environmental policies and concerns over flaring?	
6c. Do you think the interests of particular groups have played a role in limiting the implementation of gas flaring policies?	
6d. Do you consider the fine of 10 Naira is appropriate as a penalty seeking to reduce flaring?	

7. What factors are most likely to influence the decision to implement gas flaring and venting policies/regulations in Nigeria in the next four years?

Please rank from 1-3 according to importance. The number 1 choice has a weight of 1, the number 2 choice weights 2, and the number 3 choice weights 3.	**<u>Options</u>** **[1]** **[2]** **[3]**
Demand for alternative or renewable energy	
Low-cost competition	
Supply chain security	
Disruption of capital markets	
Financing costs	

Downturn in global economy	
Local content	
Inflation	
Oil / Natural gas price	
Energy Input costs	
Fraud and corruption	
Community / social activism	
Regulatory compliance	
Technology	
Inadequacy of basic infrastructure	
Environmental considerations	
People skills	

Federalism and Gas flaring Policies

8. Do you think the government should decentralise authority to the state and local governments and enable them to legislate and control gas flaring in the various gas flaring and venting states in the Niger Delta?

1=Decentralise	2=Do not Decentralise	3=Unsure

Stakeholders/Local Content

9. Do you think the local and state government priorities and politics concerning flaring match those of the national government?

1=Yes	2=No	3=Unsure

9b. If you think they are different, please explain how they differ.

……………………………………………………………………………………………

10. How significant are strong local stakeholders/ host communities' involvement in the success of the gas flaring reduction target?

1=Very important	2=Important	3=Not important	4=Undecided

Section 4 – *International Oil Companies (IOC's), Government policies, and Policy Implementation*

11. What percentage of capital expenditure (CAPEX) do you think oil and gas companies should spend on environmental issues, including gas flaring and venting abatement?

Between 5 -10%	More than 10%	Less than 5%

International Oil Companies (IOCs) and government policies on gas flaring and venting

12. Policy change and IOCs influence

12a. Where do you think the balance of power and influence is located between government policy and IOCs?	Government (%)	IOCs (%)

12b. Do you think the influence of the IOCs weakens or strengthens interest in gas flaring policy implementation, or is it neutral?	1=Weakens	2=Strengthens	3=Neutral

13. How have gas flaring and venting policies and regulations affected capital project investment decisions by the International Oil Companies (IOCs) over the years?

	1=Significant Impact	2=Medium Impact	3=No Impact

Change oil and gas project's scope			
Revised oil and gas project specification			
Cancelled most oil and gas projects			
Accelerate most of the oil and gas projects			
No impact on oil and gas projects			
Delayed or postponed oil and gas projects			

Policy implementation

14. Which of the following do you expect might create difficulties in executing gas flaring reduction strategy policies, and to what extent?

Please rank from 1-3 according to importance. The number 1 choice has a weight of 1, the number 2 choice weights 2, and the number 3 choice weights 3.	**Options** [1] [2] [3]
Inconsistent and conflicting regulatory framework	
Incoherent policies	
Oil price fluctuations	
Difficulty in securing finance	
Uncertainty in project costs	
Fraud & corruption	
Political uncertainty in the country/region	
Lack of skilled labour	
Uncertain about future taxation/royalty payments	
Higher level of project costs	
Oil / Natural gas price	
Energy Input costs	
Fraud and corruption	
Risk of physical safety of staff and Social unrest/activism	

Lack of refining capacity	
Anti-competitive practices	
Reliable/uninterrupted power supply	

Policy implementation

15. To what extent do other policies' goals override gas flaring and venting policy goals and implementation?

Please rank from 1-3 according to importance. The number 1 choice has a weight of 1, the number 2 choice weights 2, and the number 3 choice weights 3.	**Options** **[1]** **[2]** **[3]**
Economic Recovery and Growth Plan Policy	
Nigeria Vision 20:2020 policy	
Nigeria Economic Sustainability Plan 2020 policy	
Fiscal incentives NNPC policy	
Foreign Direct Investment Regime 2021 policy	
Nigeria's economic growth 2020 policy	
Nigerian Investment Promotion Commission policy	
Expansion of Treasury Single Account (TSA) coverage policy	
Agriculture Promotion Policy (2016-2020)	
Nigeria National Energy Policy 2003	
Nigeria National Gas Policy 2017	
National Integrated Infrastructure Masterplan policy	
National Policy on Climate Change (NPCC) Adaptation	
National Policy on Environment	

16. The federal government of Nigeria control significant shares within the production sharing contract (PSCs) through the Ministry of Petroleum Resources and the Nigerian National Petroleum Corporation. How do you think this affects the federal institutions' enforcement of gas flaring laws and regulations?

1=Not at all	2=Somewhat	3=Substantially

16b. Do you think it makes the enforcement weaker or stronger?

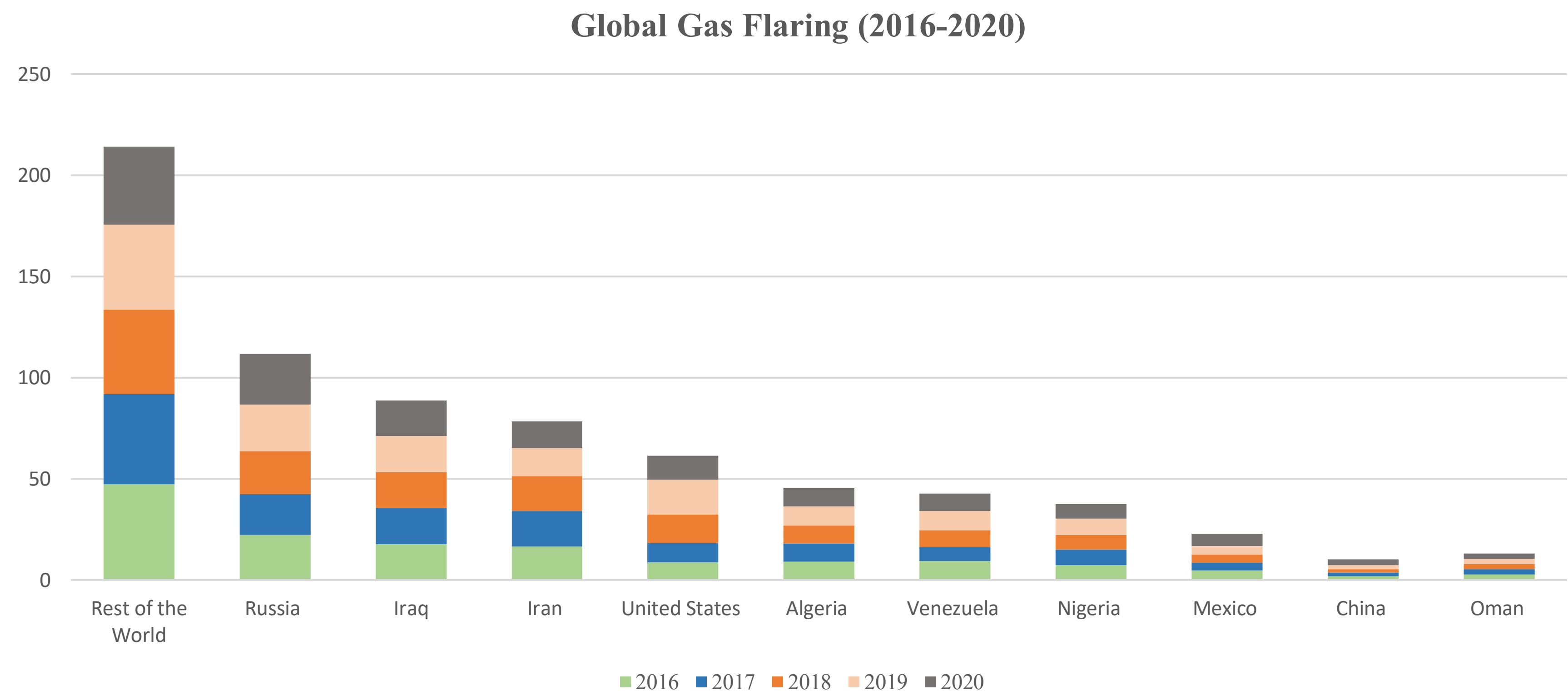
1=Weaker	2=Stronger	3=Undecided

Are there any other comments you would like to make that may be relevant to the study?

Thank you for your co-operation.

Chapter 4 Supplementary material

Supplementary material 1: Top ten countries with high gas flaring and the rest of the world in Billion Cubic Metres (Bcm) from 2016 to 2020



Global gas flaring-Top ten countries with high gas flaring and the rest of the world in Billion Cubic Metres (Bcm) from 2016 to 2020. Data source: The World Bank/GGFR (2021).

Supplementary material 2: Initial Q-statements from preliminary interviews, consultations and experts survey, and qualitative interview data

No.	Statement
1.	Rent-seeking corruption, the entrenchment of corruption exacerbates gas flaring
2.	Gas flaring promotes inequality and wealth accumulation by the elites
3.	IOC's authoritarian business models particularly in poor countries have exacerbated gas flaring over the years
4.	Vulnerable host communities are excluded from accessing high energy prices (electricity)
5.	Energy poverty is common in gas flaring host communities, particularly in developing countries.
6.	Benefits and burdens of gas flaring are not evenly distributed, and we are becoming too dependent on natural gas.
7.	Host communities bear a disproportionate share of the negative environmental consequences resulting from gas flaring and government policies.
8.	Maldistribution of environmental and social impacts of gas flaring fuels restiveness and conflicts, especially in developing countries.
9.	Gas flaring and social deprivation cause crime.
10.	Gas flaring policies have stripped host communities of the right to clean water, food, air, and a safe environment.
11.	Gas flaring host communities do not enjoy the same clean air as non-oil and gas-producing communities.
12.	Loss of jobs to expatriates/disruption to traditional businesses
13.	Government's fiscal incentives for investment in the economic utilisation of flared gas promote flaring.
14.	The decision-makers seek out and facilitate the involvement of those host communities potentially affected by gas flaring.
15.	Host communities' concerns are considered in gas flaring decision-making processes.
16.	Governments should use public input in making decisions about gas flaring.
17.	Governments should set up an advisory group of community leaders to review what the agencies are doing.
18.	There should be an independent community watchdog group to examine and monitor government regulatory agencies' and IOCs' activities.
19.	State and local government agencies and officials should be involved in gas flaring decisions.
20.	Regulatory bodies' staff should be sufficiently knowledgeable about the technical issues.
21.	Energy price increases further marginalise deprived gas flaring host communities and exacerbate vulnerability
22.	Maldistribution and not recognising gas flaring host communities in decisions about flaring fuels restiveness and conflicts, especially in developing countries.
23.	Exclusion of those living in the host communities from decisions concerning gas flaring is necessary for the governments and IOCs.
24.	Enclave structure exacerbates gas flaring, injustice, socio-economic marginalisation, and dispossession in the host communities.
25.	Host communities should have an opportunity to participate in decisions about gas flaring
26.	The public's contribution has influenced the regulatory agency's decision on gas flaring.

27. The impacts of gas flaring and climate change would fall disproportionately on already vulnerable gas flaring populations.
28. Gas flaring contributes to extreme forms of socio-economic marginalisation.
29. Governments of gas flaring nations deliberately suppress gas flaring data and scientific data for political gain
30. Oil and gas giants back anti-gas flaring lobby groups despite pledges while fuelling climate change.
31. Countries without oil and gas have stringent environmental laws sufficiently stringent
32. Gas flaring nations need to compensate others for climate change impacts due to transboundary pollution.
33. Gas flaring is a source of major environmental problems and needs significant modification.
34. Oil and gas companies that cause environmental damage should be more heavily punished.
35. Governments and IOCs should feel guilty if they cause pollution incidents, whatever the cause.
36. Environmental and health harm to gas flaring is a source of shame for those who cause it.
37. IOCs should always protect the local host communities regardless of what incentive is available from their host country.
38. The more money you make from gas flaring, the more you should be willing to spend on enhancing welfare and the environment and other environmental concerns.
39. Information concerning gas flaring the IOCs and oil and gas producing countries are reporting should be unbiased and accurate.
40. Gas flaring is the world's biggest emission problem and capping gas flaring is the key to solving climate change.
41. Flaring should be banned worldwide and countries that flare gas should be banned.
42. The conditions in and around gas flaring host communities must conserve livelihood and lifestyles.
43. Global gas flaring is preventable emissions and practice can be stopped through legislation.
44. Gas flaring emits black carbon, methane, and volatile organic compounds and contributes to climate change
45. Enough is being done to protect and enhance the host communities' environment currently.
46. Gas flaring reduction is in a better state now than it has ever been.
47. Oil and Gas Companies and gas flaring countries have a greater responsibility to produce energy through fossil fuel development than to preserve the rural environment.
48. A successful oil and gas sector is important for the vitality of rural gas flaring host communities.
49. Many of the justice issues and health impacts caused by gas flaring that environmental campaigners/NGOs want to protect are not worth worrying about.
50. Gas flaring should be continued because revenue generation is more important than gas flaring.
51. Gas flaring and pollution of host communities are acceptable in some extreme cases
52. Corruption in the oil and gas industry can be acceptable in some cases.
53. Voluntary disclosure is acceptable in greenhouse gas emissions reduction and flaring voluntary environmental programs should reduce emissions

54. The dangers of gas flaring are exaggerated, gas flaring does not interfere with human activities, and gas flaring is not a crime and does not exist
55. Greenhouse gas emissions through routine flaring are widespread among energy companies as part of crude oil production.

Supplementary material 3: Develop the concourse

We sampled the concourse using four theoretically driven criteria:

1. Specific preference was given to articles that include gas flaring, energy and environmental justice, low carbon energy system and transition concept.
2. Articles with a comprehensive overview of gas flaring in energy/environmental justice, production and systems, consumption, activism, energy security, and climate change.
3. Articles that include and underscore all the concepts.
4. No emphasis and preference for date of publications.

The results were sorted based on the four criteria without considering the publication date and resulted in a total of 393 articles. Following Steelman and Maguire's (1999) approach, an unstructured sampling approach was utilised for statement sampling to develop the Q-set.

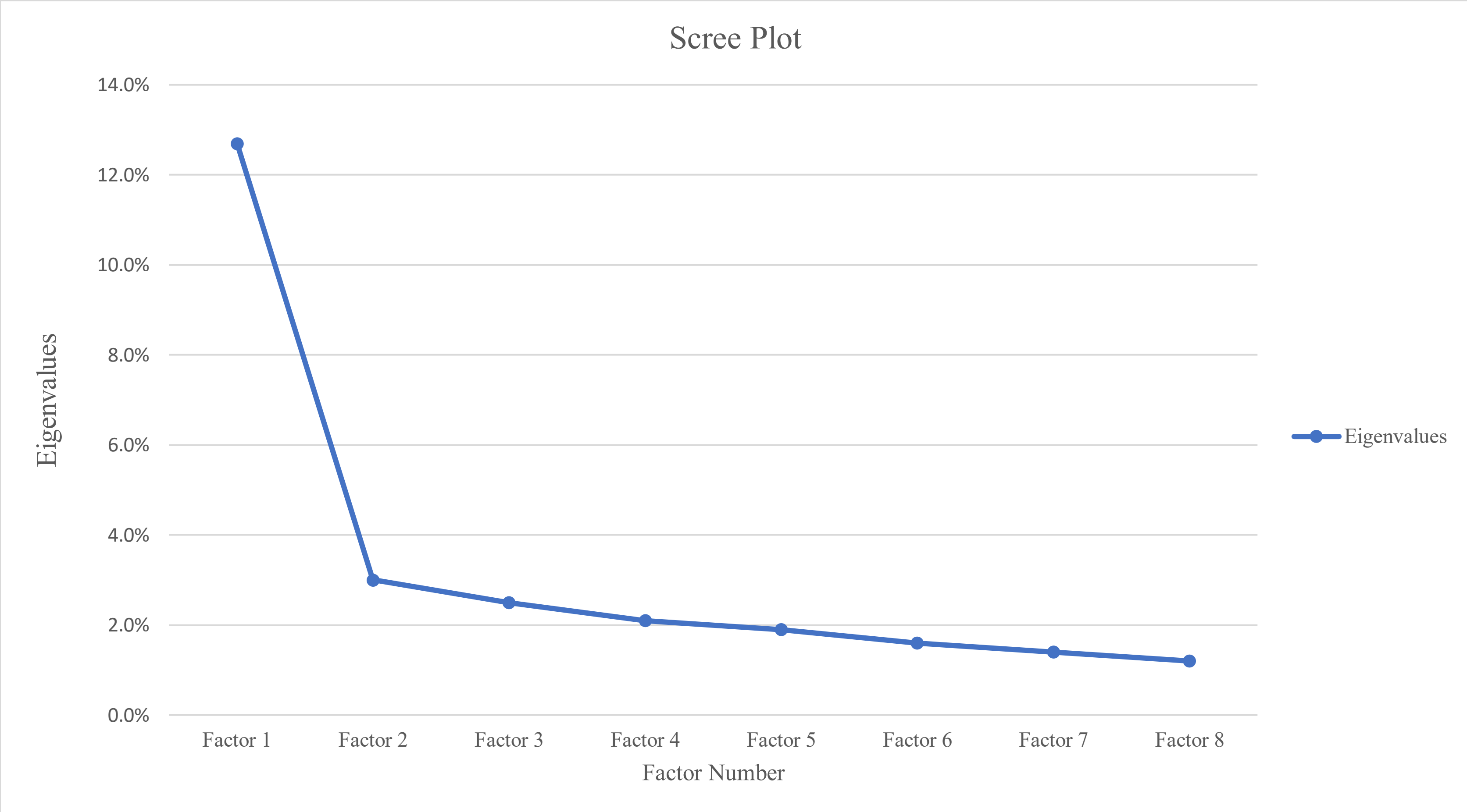
The corpus was limited to English language publications. Literature considered included extracts from articles on gas flaring and environmental justice, websites and social/professional network message boards, online newspaper articles, press releases from gas exploration companies, government statements on gas flaring, grassroots activists/environmental campaigners, and NGO publications.

Supplementary material 4: Unrotated Factor Matrix

Participant	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
15YT	0.51568	0.41172	0.31444	-0.23374	-0.158	-0.08512	-0.26861	-0.12176
1ZEHM58	0.18835	0.83689	-0.05738	-0.08554	-0.08825	-0.04795	0.19099	0.00455
2WDSJC	0.5876	-0.40212	-0.17751	-0.0757	0.02589	-0.03506	0.5242	0.15014
3HIBT	0.45939	0.05136	0.44434	-0.37581	-0.30621	-0.17732	0.03273	-0.15375
5P9NBFU5	0.6801	0.04935	-0.39223	0.10013	0.0551	-0.01916	0.0633	-0.09506
6I62	0.78031	-0.12103	-0.22688	0.23214	-0.06027	0.04069	-0.25152	-0.01676
72G38DG	0.86697	0.15546	-0.05893	0.08843	0.06881	-0.10924	-0.02491	0.06524
8DGFJ	0.55189	0.0926	0.26842	0.53567	-0.16547	-0.0806	0.13297	-0.2464
AR9L	0.38734	0.05742	0.23022	-0.31937	-0.13911	-0.23373	-0.33894	0.36936
AY2DBB6	0.74466	-0.15919	-0.01442	-0.23607	-0.16961	0.03944	0.19705	0.09061
B2MP	0.2523	0.01992	0.29649	-0.06653	0.5977	0.45032	0.21774	-0.02714
BQHJS8	0.85134	-0.098	-0.24333	0.17982	-0.04174	0.04053	-0.20411	-0.15764
C1BQUI	0.76152	0.16594	-0.35661	-0.0122	-0.0891	0.05432	-0.01037	0.0083
CT8E0R	0.4128	0.3176	0.2927	0.56717	0.16636	0.07284	0.01527	-0.00897
CWQQ	0.45634	0.38072	0.14801	0.51036	0.19065	0.0761	-0.15802	0.28435
D05E86	0.56996	-0.37066	-0.12139	0.09806	-0.18436	0.06429	-0.40394	0.17886
FD84	0.25228	0.43393	-0.45059	-0.39694	-0.04393	0.41718	0.0293	-0.16936
JGNMN45	0.71876	-0.11495	-0.04646	-0.09611	-0.27099	0.11716	0.04261	0.15149
L4MA87P	0.71784	0.30547	0.12961	0.04184	-0.19575	0.0899	-0.10741	-0.22872
LI7GQN6	0.51669	-0.25518	0.03751	-0.14438	0.47006	0.26659	-0.01521	0.18129
M344Q1NE	0.09615	0.0411	0.20019	0.20657	-0.49149	0.64926	0.26167	-0.04719
M87O	0.28282	0.43807	0.22499	-0.30806	0.21027	0.12459	0.18972	0.39933
OKFO9NXA	0.50586	-0.21554	0.23993	0.09126	-0.32102	-0.10746	0.39444	-0.2706
OQ4HCTYW	0.48047	-0.26168	0.19172	0.16874	0.24349	0.41339	-0.27185	-0.07765

PAN5RJT4	0.7294	-0.28007	-0.026	-0.31536	0.24649	-0.13778	0.05194	-0.25453
QJ0A	0.81123	0.07324	-0.15702	0.04157	0.13397	-0.18424	-0.18355	-0.12989
QTAEH	0.68679	-0.52962	-0.10806	-0.21012	0.17327	-0.01461	0.00135	-0.17819
S6E3	0.27452	-0.06431	0.65089	-0.30041	0.14693	0.12553	-0.18762	-0.29685
UL38W	0.74292	-0.12568	-0.3097	0.16454	0.02418	-0.01642	0.18552	0.12602
V0IE	0.63363	0.31046	0.18056	-0.08134	0.28438	-0.28048	0.20622	0.04798
VUZN	0.69566	0.2071	-0.19857	0.16908	0.11536	-0.27112	0.15571	0.06408
VY90ID	0.90592	0.00525	0.22021	-0.06254	0.02026	0.0349	-0.02553	0.01514
WLNFAP0	0.49207	-0.24624	0.20597	-0.08105	-0.4709	0.23215	-0.01221	0.42638
X03A	0.07788	0.4446	-0.5461	-0.32579	-0.06286	0.30032	-0.15038	-0.14043
YJ3O7	0.84911	0.03035	0.09132	-0.12687	-0.02863	-0.18035	0.01537	0.09604

Supplementary material 5: Scree plot of factor Eigenvalues



Chapter 5 Appendices

Normalised Tables

Appendix 5A: Table A1. Main Criteria Group A

	Policy and Targets	Legal, Regulatory, Framework and Contractual	Regulatory Governance and Organisation	Licensing and Process Approval	Measurement and Reporting	Fines, Penalties and Sanctions	Enabling Framework	Priority	Rank
Policy and Targets	1.00	2.00	3.00	4.00	3.00	4.00	6.00	31%	1
Legal, Regulatory, Framework and Contractual	0.50	1.00	2.00	4.00	3.00	4.00	4.00	23%	2
Regulatory Governance and Organisation	0.33	0.50	1.00	3.00	4.00	3.00	5.00	18%	3
Licensing and Process Approval	0.25	0.25	0.33	1.00	3.00	4.00	4.00	12%	4
Measurement and Reporting	0.33	0.33	0.25	0.33	1.00	3.00	4.00	8%	5
Fines, Penalties and Sanctions	0.25	0.25	0.33	0.25	0.33	1.00	4.00	5%	6
Enabling Framework	0.17	0.25	0.20	0.25	0.25	0.25	1.00	3%	7
	0.31	0.23	0.18	0.12	0.08	0.05	0.03		

Appendix 5B: Table A2. Main Criteria Group B

	Policy and Targets	Legal, Regulatory, Framework and Contractual	Regulatory Governance and Organisation	Licensing and Process Approval	Measurement and Reporting	Fines, Penalties and Sanctions	Enabling Framework	Priority	Rank
Policy and Targets	1	0.33	0.25	0.17	0.17	0.14	0.11	2%	7
Legal, Regulatory, Framework and Contractual	3	1	0.33	0.25	0.17	0.14	0.17	3%	6
Regulatory Governance and Organisation	4	3	1	0.33	0.2	0.2	0.25	6%	5
Licensing and Process Approval	6	4	3	1	0.33	0.2	0.2	9%	4
Measurement and Reporting	6	6	5	3	1	0.33	0.25	16%	3
Fines, Penalties and Sanctions	7	7	5	5	3	1	0.33	26%	2
Enabling Framework	9	6	4	5	4	3	1	37%	1
	0.02	0.03	0.06	0.09	0.16	0.26	0.37		

Appendix 5C: Table A3. Policy and Targets Group A

	Background and the Role of Reductions	Targets and limits	Priority	Rank
Background and the Role of Reductions	1.00	5.00	83%	1
Targets and limits	0.20	1.00	17%	2
	0.83	0.17		

Appendix 5D: Table A4. Policy and Targets Group B

	Background and the Role of Reductions	Targets and limits	Priority	Rank
Background and the Role of Reductions	1.00	0.20	17%	2
Targets and limits	5.00	1.00	83%	1
	0.17	0.83		

Appendix 5E: Table A5. Legal, Regulatory, Framework and Contractual Group A

	Primary & Secondary Legislation & Regulation	Legislative Jurisdictions	Associated Gas Ownership	Priority	Rank
Primary & Secondary Legislation & Regulation	1.00	4.00	6.00	69%	1
Legislative Jurisdictions	0.25	1.00	3.00	22%	2
Associated Gas Ownership	0.17	0.33	1.00	9%	3
	0.690951	0.217648	0.091401		

Appendix 5F: Table A6. Legal, Regulatory, Framework and Contractual Group B

	Primary & Secondary Legislation & Regulation	Legislative Jurisdictions	Associated Gas Ownership	Priority	Rank
Primary & Secondary Legislation & Regulation	1.00	0.25	0.20	9%	3
Legislative Jurisdictions	4.00	1.00	0.33	28%	2
Associated Gas Ownership	5.00	3.00	1.00	63%	1
	0.09	0.28	0.63		

Appendix 5G: Table A7. Regulatory Governance and Organisation Group A

	Regulatory Authority	Regulatory Mandates and Responsibilities	Monitoring and Enforcement	Development Plans	Economic Evaluation	Priority	Rank
Regulatory Authority	1.00	3.00	3.00	4.00	5.00	43%	1
Regulatory Mandates and Responsibilities	0.33	1.00	2.00	3.00	4.00	23%	2
Monitoring and Enforcement	0.33	0.50	1.00	5.00	5.00	21%	3
Development Plans	0.25	0.33	0.20	1.00	3.00	8%	4
Economic Evaluation	0.20	0.25	0.20	0.33	1.00	5%	5
	0.43	0.23	0.21	0.08	0.05		

Appendix 5H: Table A8. Regulatory Governance and Organisation Group B

	Regulatory Authority	Regulatory Mandates and Responsibilities	Monitoring and Enforcement	Development Plans	Economic Evaluation	Priority	Rank
Regulatory Authority	1.00	0.25	0.20	0.25	0.17	4%	5
Regulatory Mandates and Responsibilities	4.00	1.00	0.20	0.20	0.25	8%	4
Monitoring and Enforcement	5.00	5.00	1.00	0.50	0.33	20%	3
Development Plans	4.00	5.00	2.00	1.00	0.50	27%	2
Economic Evaluation	6.00	4.00	3.00	2.00	1.00	40%	1
	0.04	0.08	0.20	0.27	0.40		

Appendix 5I: Table A9. Licensing and Process Approval Group A

	Flaring or Venting without Prior Approval	Authorised Flaring or Venting	Priority	Rank
Flaring or Venting without Prior Approval	1.00	6.00	86%	1
Authorised Flaring or Venting	0.17	1.00	14%	2
	0.86	0.14		

Appendix 5J: Table A10. Licensing and Process Approval Group B

	Flaring or Venting without Prior Approval	Authorised Flaring or Venting	Priority	Rank
Flaring or Venting without Prior Approval	1.00	0.20	17%	2
Authorised Flaring or Venting	5.00	1.00	83%	1
	0.17	0.83		

Appendix 5K: Table A11. Measurement and Reporting Group A

	Measurement and Reporting Requirements	Measurement Frequency and Methods	Engineering Estimates	Record Keeping	Data Compilation and Publishing	Priority	Rank
Measurement and Reporting Requirements	1.00	3.00	4.00	3.00	4.00	44%	1
Measurement Frequency and Methods	0.30	1.00	3.00	3.00	3.00	25%	2
Engineering Estimates	0.25	0.33	1.00	3.00	2.00	14%	3
Record Keeping	0.33	0.33	0.33	1.00	1.00	8%	4
Data Compilation and Publishing	0.25	0.33	0.50	1.00	1.00	8%	5
	0.44	0.25	0.14	0.08	0.08		

Appendix 5L: Table A12. Measurement and Reporting Group B

	Measurement and Reporting Requirements	Measurement Frequency and Methods	Engineering Estimates	Record Keeping	Data Compilation and Publishing	Priority	Rank
Measurement and Reporting Requirements	1.00	0.25	0.33	0.20	0.13	4%	5
Measurement Frequency and Methods	4.00	1.00	0.50	0.25	0.25	9%	4
Engineering Estimates	3.00	2.00	1.00	0.33	0.33	12%	3
Record Keeping	5.00	4.00	3.00	1.00	0.20	24%	2
Data Compilation and Publishing	8.00	4.00	3.00	5.00	1.00	51%	1
	0.04	0.09	0.12	0.24	0.51		

Appendix 5M: Table A13. Fines, Penalties and Sanctions Group A

	Monetary Penalties	Nonmonetary Penalties	Priority	Rank
Monetary Penalties	1	4	80%	1
Nonmonetary Penalties	0.25	1	20%	2
	0.8	0.2		

Appendix 5N: Table A14. Fines, Penalties and Sanctions Group B

	Monetary Penalties	Nonmonetary Penalties	Priority	Rank
Monetary Penalties	1.00	0.14	13%	2
Nonmonetary Penalties	7.00	1.00	88%	1
	0.13	0.88		

Appendix 5O: Table A15. Enabling Framework Group A

	Performance Requirements	Fiscal and Emission Reduction Incentives	Use of Market-Based Principles	Negotiated Agreements-Public & Private Sector	Interplay with Midstream and Downstream RF	Priority	Rank
Performance Requirements	1	3	4	4	3	43%	1
Fiscal and Emission Reduction Incentives	0.3	1	4	4	5	30%	2
Use of Market-Based Principles	0.3	0.3	1	2	2	11%	3
Negotiated Agreements-Public & Private Sector	0.3	0.3	0.5	1	2	9%	4
Interplay with Midstream and Downstream RF	0.3	0.2	0.5	0.5	1	7%	5
	0.43	0.30	0.11	0.09	0.07		

Appendix 5P: Table A16. Table A6. Enabling Framework Group B

	Performance Requirements	Fiscal and Emission Reduction Incentives	Use of Market-Based Principles	Negotiated Agreements-Public & Private Sector	Interplay with Midstream and Downstream RF	Priority	Rank
Performance Requirements	1.00	0.25	0.25	0.20	0.11	4%	5
Fiscal and Emission Reduction Incentives	4.00	1.00	0.50	0.20	0.25	9%	4
Use of Market-Based Principles	4.00	2.00	1.00	0.33	0.25	12%	3
Negotiated Agreements-Public & Private Sector	5.00	5.00	3.00	1.00	0.20	24%	2
Interplay with Midstream and Downstream RF	9.00	4.00	4.00	5.00	1.00	52%	1
	0.04	0.09	0.12	0.24	0.52		